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THE VALUE OF SEVERAL NON-PROTEIN-NITROGEN COMPOUNDS AS PROTEIN SUBSTITUTES IN LAMB FATTENING RATIONS [1]

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ONLY limited work has been conducted with non-protein nitrogen (NPN) compounds other than urea, as nitrogen sources in the nutrition of ruminants. Ehrenberg *et al.* (1932, 1933), Windheuser *et al.* (1936), Kirsch and Jantzon (1934) and Hart *et al.* (1939) reported that ammonium bicarbonate could partially replace the protein in rations for dairy cattle. NPN compounds found to be successful protein substitutes in rations for goats were ammonium acetate (Paasch, 1925), and ammonium nitrate (Kametaka *et al.*, 1953). Schmidt *et al.* (1937 reported no utilization by milk cows of the nitrogen of glycine, whereas Ehrenberg *et al.* (1939) found glycine to be about 30 percent as efficient as oil cake in terms of milk production. At present urea is the only commercial NPN feeding compound being used as a protein replacement in ruminant rations; thus it seemed desirable to compare urea with several other NPN compounds as protein replacements, and also to compare these compounds with protein from natural feed sources.

Experimental Procedure

The study consisted of three feeding experiments. The lambs in Experiments I and II were group fed and those in Experiment III were individually fed. *In vitro* studies involving adaptation of the rumen microorganisms to utilization of certain NPN compounds were conducted in conjunction with Experiments II and III.

In Experiment I, 50 feeder lambs averaging about 75 lb. in weight were allotted into five lots of 10 lambs each. At the start of the feed-

[1] Journal paper No. J-2726 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project No. 1208.

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[3] This work was supported in part by a grant from E. I. du Pont de Nemours & Co., Wilmington, Delaware.

[4] The authors wish to express acknowledgment to Professor P. H. Homeyer for advice on statistical analysis of the data and to Mr. Victor A. Applegate of the ruminant nutrition laboratory.

[5] Ames, Iowa.

ing period, the lambs received 2 lb. of corn silage plus 1 lb. of the experimental ration per head, daily. By the 14th day, the lambs were on a full feed of the experimental ration, and the corn silage had been removed. The five NPN compounds fed in this trial were urea, ammonium propionate, formamide, propionamide and ammonium formate. The basal ration is shown in table 1. The basal ration with added urea

TABLE 1. COMPOSITION OF BASAL RATIONS

Ingredients	Experiments I and II	Experiment III
	%	%
Ground corncobs	20.00	16.00
Ground clover hay	10.00	20.00
Cracked corn	42.20	44.18
Cane molasses	25.93	17.00
Soybean oil meal	.....	1.00
Mono-calcium phosphate	.80	.80
Ground limestone	.80	.....
Iodized salt	.15	1.00
Trace minerals [a]	.08	.....
A and D oil (2350 A—400 D)	.04	.02
Total	100.00	100.00

[a] A commercial trace mineral premix for ruminants containing Cu., Co., Fe., Mn. and Zn.

served as the control. Urea and the other NPN compounds were fed at levels such that they supplied 50 percent of the total nitrogen in their respective rations. When expressed as a percentage of the various rations the NPN compounds were added at the following rates: urea, 2.20 percent; ammonium propionate, 8.23 percent; formamide, 3.10 percent; propionamide, 4.80 percent; and ammonium formate, 4.15 percent. All additions were made at the expense of corn. Each ration contained 11.6 percent protein equivalent.

In Experiment II, eight lots of 20 lambs averaging about 70 lb. were fed rations similar to those used in Experiment I except that formamide was dropped as a test compound and ammonium acetate was included. In this test both a negative control (low-nitrogen basal ration) and a positive control (soybean oil meal supplying necessary protein) were used. The protein content of the low-nitrogen ration was 6.1 percent; all other rations had a protein equivalent content of 11.6 percent. The test compounds were added at the following levels to supply 50 percent of the nitrogen in the ration: soybean oil meal, 15.50 percent; urea, 2.20 percent; ammonium propionate, 8.20 percent; propionamide, 5.32

percent; ammonium formate, 4.13 percent; and ammonium acetate, 5.00 percent. All additions were at the expense of the corn. The lambs were started on hay and the experimental ration and by two weeks were receiving a full feed of the experimental ration only.

Experiment III was planned on the basis of results obtained in the first two experiments and in previous toxicity studies (Repp *et al.* (1955). In this trial, urea and propionamide were each fed at two nitrogen levels such that they furnished 15 percent and 30 percent of the protein equivalent of the ration. Positive and negative control rations were used as in Experiment II. The basal ration is shown in table 1. The protein equivalent content of the low-nitrogen basal ration was 7.4 percent and that of the test rations was 10.5 percent. All lambs in this experiment were fed individually, eight lambs comprising the positive control group (conventional protein) and seven lambs making up each of the other treatment groups.

At the completion of the feeding phase of Experiment II, two lambs, one from the conventional protein group and one from the propionamide group, were sacrificed and the entire rumen contents collected. Similarly, seven lambs from Experiment III (three receiving the conventional protein and four receiving the ration in which propionamide furnished 30 percent of the protein equivalent) were sacrificed. Rumen microorganisms were separated from the rumen contents of each of the lambs. The microorganisms were incubated with a given amount of either propionamide or urea by the artificial rumen technique as developed by Burroughs *et al.* (1950) and modified by Cheng (1953). At intervals of 2, 4, 8, 12, and 24 hours, fermentation tubes were removed, centrifuged for 5 minutes at 5,000 r.p.m. and an aliquot of the supernatant analyzed for ammonia nitrogen by the method of Van Slyke and Cullen (1914). Control tubes to which no NPN compound was added were used as the blanks.

Results and Discussion

The results of Experiment I are presented in table 2. Several of the lambs failed to respond; consequently, they were removed from the experiment. Only data for those lambs finishing the test are included in table 2. Lambs fed urea, ammonium propionate, and ammonium formate made satisfactory gains. The lambs receiving formamide and propionamide made significantly lower ($P = .01$) rates of gain than the others; however, daily feed consumption for the lambs fed propionamide was good (3.08 lb.). Some of the lambs fed formamide developed a paralysis of the rear quarters which appeared to be due to toxicity peculiar to

TABLE 2. EFFECT OF NPN FEEDING COMPOUNDS ON WEIGHT GAINS AND FEED CONSUMPTION OF LAMBS

Exp. I—56 Days

Treatment	No. of lambs	Daily gain per lamb	Daily feed consumption
		lb.	lb.
Urea	9	.39	3.61
Ammonium propionate	8	.34	2.67
Ammonium formate	10	.42	3.61
Formamide	8	.14	2.37
Propionamide	8	.25	3.08

this compound; therefore, no further feeding trials were conducted with this material. Some difficulty was encountered in keeping the lambs fed ammonium propionate on full feed. This may have been due to the ammonia odor of the ration containing this compound.

In Experiment II, several of the lambs failed to respond and were removed. Only data for those lambs finishing the test are included in the results. It was believed that treatment was not involved in the failure of the lambs in Experiments I and II to respond to their rations and it was on this assumption that they were removed from the test. Results of Experiment II are presented in table 3.

In Experiment II the lambs receiving the NPN compounds were slow in going on full feed. If the gains of the last 53 days are compared with those of the entire 74-day trial, it can be seen that the 53-day gains are similar to those made by lambs on conventional protein (treatment 2). This result suggests that a period of 2–3 weeks was required for either

TABLE 3. EFFECT OF NPN FEEDING COMPOUNDS ON WEIGHT GAINS AND FEED CONSUMPTION OF LAMBS

Exp. II—74 Days

Treatment	No. of lambs	Av. daily gains		Daily feed consumed
		74 days	Last 53 days	
		lb.	lb.	lb.
1. Low nitrogen	17	.21	.26	2.81
2. Conventional protein	20	.40	.41	3.60
3. Urea	17	.29	.41	3.23
4. Propionamide	20	.29	.37	3.53
5. Ammonium formate	18	.35	.46	3.52
6. Ammonium propionate	19	.31	.39	3.24
7. Ammonium acetate	18	.35	.45	3.42
8. Ammonium acetate	20	.32	.38	3.40

the lambs or rumen microorganisms to fully adapt themselves to the various NPN compounds. The lambs receiving the low-nitrogen ration made slower rates of gain ($P = .01$) during both periods than the lambs on any other treatment. Over the entire 74 days, lambs fed conventional protein made greater rates of gain ($P = .01$) than those fed any of the NPN compounds. However, during the last 53 days there was no difference in rates of gain between the lambs of treatment 2 and NPN fed lambs. These data suggest that after the animals become accustomed to the NPN compounds, performance similar to that obtained with conventional protein rations can be expected. These trials were conducted at a 50 percent protein equivalent replacement level which is much higher than would likely be feasible in feeding practice.

In Experiment III, propionamide and urea were tested, urea serving

TABLE 4. EFFECT OF NPN FEEDING COMPOUNDS ON WEIGHT GAIN AND FEED CONSUMPTION OF INDIVIDUALLY FED LAMBS

Exp. III—56 Days

Treatment	No. of lambs	Av. daily gain	Av. daily feed consumed
		lb.	lb.
1. Conventional protein	8	.52	3.90
2. Low nitrogen	7	.37	3.61
3. Propionamide 15% of protein equivalent	7	.44	3.72
4. Propionamide 30% of protein equivalent	7	.50	4.00
5. Urea 15% of protein equivalent	7	.43	3.71
6. Urea 30% of protein equivalent	7	.46	4.11

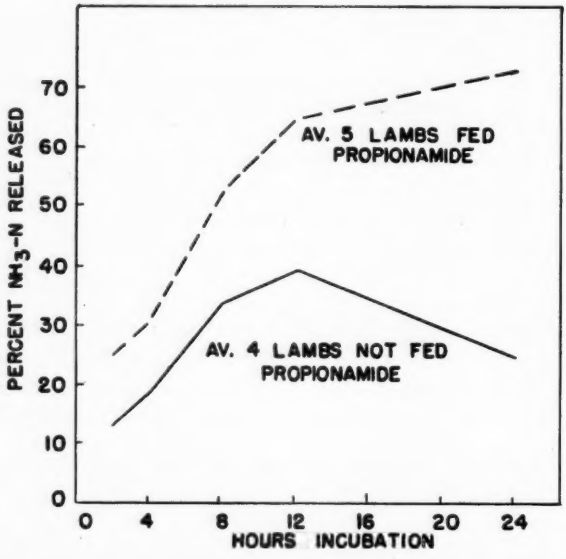
as the control NPN compound and propionamide as the test compound. Propionamide was singled out primarily because of its low toxicity (Repp *et al.* 1955). The rations used in this experiment as compared to Experiments I and II were more nearly like those used in feeding practice. The results are shown in table 4.

There was no difference in rate of gain between lambs fed propionamide and those fed urea at equivalent levels. Similarly, there was no difference between those fed conventional protein and those fed NPN. The difference between treatments 1 and 2 was significant ($P = .01$). Lambs fed propionamide made greater gains ($P = .05$) than those fed

the low-nitrogen ration, but those fed urea did not. When considered as a group, however, all NPN-fed lambs gained faster ($P = .05$) than the low-nitrogen lambs. In this experiment all gains were excellent, and the lambs appeared to be able to utilize the NPN compounds when first offered. This may have been due in part to the type of ration fed.

Results of the *in vitro* studies with the rumen microorganisms are presented in figure 1. It can be seen that the microorganisms from the

FIGURE 1. AVERAGE RATE OF RELEASE OF NH_3-N FROM PROPIONAMIDE INCUBATED WITH LAMB RUMEN MICROORGANISMS.



lambs which had received propionamide in the feeding trials released more ammonia nitrogen from propionamide than did the microorganisms from the control lambs. This difference in ammonia release was significant ($P = .01$). Analysis of the data also showed that the differences in percentage ammonia nitrogen released by the bacteria from the propionamide-fed lamb at the five sampling intervals were significant ($P = .05$), indicating a continuing increase of ammonia nitrogen release with time. The test lambs had been fed propionamide for periods of 5 to 90 days. The data on an individual lamb basis suggested that

the longer the lamb had been fed propionamide the greater the release of ammonia nitrogen by the rumen microorganisms. The rumen microorganisms from either group of test lambs released about 90 percent of the ammonia nitrogen from urea during the first two hours of incubation (Repp, 1955). After the rumen microorganisms became adapted to the propionamide the ammonia nitrogen release from this compound was approximately one-half the rate at which it was released from urea (Repp, 1955).

In the feeding Experiments II and III, there were no significant differences in weight gains between lambs fed the different NPN compounds. Results of Experiment II suggest that when NPN compounds are used at high replacement levels, a period of 2–3 weeks is required for the lambs to become adjusted to the NPN compound. This may be the reason urea has failed to promote satisfactory rates of gains in some experimental work. This suggestion is in agreement with the results obtained with propionamide in the *in vitro* study. It appears from these results that the rate of ammonia release from propionamide, especially after an adaptation period, is sufficiently rapid to furnish nitrogen for adequate protein synthesis by rumen microorganisms.

The ammonium salts of the organic acids tested gave excellent rates of gain but since they are equally as toxic as urea (Repp *et al.*, 1955) they hold no special merit over urea as possible NPN feeding compounds. Propionamide, on the other hand, appears to have merit from toxicity considerations; however, it contains only about 40 percent as much nitrogen as urea and, at present, is more expensive per unit of nitrogen. The three carbon chain may be one of the keys to its usefulness in ruminant nutrition. McClymont (1953) has called attention to the fact that propionate is a very important metabolite in the energy metabolism of ruminants.

Summary

Three feeding experiments were conducted with lambs to determine the comparative feeding value of several non-protein nitrogen (NPN) feeding compounds. The compounds studied were urea, ammonium acetate, ammonium propionate, ammonium formate, formamide and propionamide. These compounds replaced as much as 50 percent of the protein nitrogen of the ration. Formamide was found inferior to the other compounds tested. The remaining NPN compounds appeared to be of about equal value in supporting growth as measured by weight gains of lambs. In one experiment, at the 50 percent nitrogen replacement level, the NPN compounds did not support as high rates of gain

as conventional protein. However, in another experiment, at the 15 percent and 30 percent replacement levels, weight gains with propionamide and urea were equal to those with conventional protein. Growth data suggested that a period of 2–3 weeks was required for the lambs to become fully adapted to the NPN compounds. This was verified by *in vitro* studies in which rumen microorganisms from lambs previously fed propionamide released significantly more ammonia nitrogen from propionamide than did the rumen microorganisms from lambs which had not been so fed.

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RESPONSE OF LAMBS FED VARIED LEVELS OF DIETHYLSTILBESTROL [1, 2]

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EXPERIMENTAL work with diethylstilbestrol (stilbestrol) implantation in lambs has been reviewed by Sykes *et al.* (1953). It has been generally agreed that stilbestrol implantation in fattening lambs will markedly improve rates of gains but subsequent carcass quality is usually lowered. The reports appearing since July, 1952, verify these findings in addition to possible toxic effects on the lamb. Jordan (1953) and Bell *et al.* (1954) have shown, with ewe lambs, that stilbestrol implantation may cause prolapse of the uteri and rectal prolapse with wether lambs. Also with wether lambs a condition resembling urinary calculi occurs. This condition is apparently due to hypertrophy of certain secondary sex organs causing a closure of the urethra. A report by Burroughs *et al.* (1954) indicated that with fattening steers the oral administration of small daily doses of stilbestrol resulted in marked improvement in rate of gains with no apparent undesirable effect upon carcass grade. No abnormal activities were noted in the feed lot. The purpose of the experiments herein reported was to determine the value of stilbestrol when fed orally in connection with lamb fattening rations.

Methods and Materials

This study is divided into 4 individual and two group feeding experiments. In the individual feeding experiments four lambs were allotted at random to rations from outcome groups based upon weight. The lambs were fed a mixed ration and were allowed to feed from an individual self feeder 3 hours at each of two feedings per day. The starting ration is listed in table 1. The hay was reduced and the corn increased a corresponding amount so that by the 20th day the lambs were receiv-

[1] Journal paper No. J-2764 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project No. 869.
[2] The ground corn cobs used in this study were supplied by John Clay Co., Kansas City, Missouri and the feeding fat by Wilson and Co., Cedar Rapids, Iowa. Carcass grade and yield on the group-fed animals was made possible through cooperation of Wilson and Co., Cedar Rapids, Iowa. Acknowledgment is made to Mr. Victor Applegate of the Ruminant Nutrition Laboratory for his assistance.
[3] Ames, Iowa.

ing a ration that contained only 35 percent hay. All stilbestrol additions were mixed with the ration on the basis of stilbestrol per lb. of ration rather than being supplied daily in a supplement. The levels of stilbestrol tested ranged from 150 mcg. to 1200 mcg. per lb. of ration in multiples of 150 mcg. However, all possible 6 levels did not appear in any one experiment. These additions supplied from 0.5 mg. to 4.7 mg. stilbestrol per lamb per day. All individually fed lambs were weighed at 14-day intervals. In Experiment 4 one of the groups receiving the 600 mcg. level of stilbestrol had 3 percent fat added to the ration at the expense of the corn. The length of the feeding periods for the individually fed animals ranged from 56–84 days.

TABLE 1. RATIONS FOR EXPERIMENTAL LAMBS

Starting ration for individually fed lambs		Mixture for group fed lambs	
	lb.		lb.
Ground alfalfa hay	50.0	Ground cobs	27.0
Cane molasses	15.0	Cane molasses	17.0
Cracked corn	33.0	Cracked corn	42.1
Urea	.8	Soybean oil meal	6.4
CaH_2PO_4	.5	Urea	1.4
Salt	.7	Bone meal with cobalt [a]	1.0
		Fat	5.0
	100.0	Vitamin A concentrate 2.5 m. units/lb.	.1
			100.0

[a] One ounce $CoSO_4 \cdot 7H_2O$ per 250 lb. Bone Meal.

Two rations were used for the group-fed lambs. The first was a conventional shelled corn, soybean oil meal, alfalfa hay ration. The stilbestrol additions were given twice daily in the soybean oil meal supplement. The two levels of stilbestrol fed were 1.8 mg. and 3.6 mg. per lamb per day. This was equivalent to 600 mcg. and 1200 mcg. per lb. of ration. The second ration for the group-fed lambs was a mixed ration containing ground corn cobs and a feeding grade animal fat. This mixture is given in table 1. In addition to the mixture, 0.3 lb. of chopped alfalfa hay per lamb per day was also fed. Stilbestrol was incorporated in the mixture at the rate of 600 mcg. and 1200 mcg. per lb. of feed. All group-fed lambs were hand full-fed twice daily. The roughage fed was limited so that the concentrate to roughage ratio was approximately 60:40.

Two pens of twenty lambs each were allotted at random to treatment in each of the group-fed experiments from outcome groups based upon weight. All group-fed lambs were weighed at 21-day intervals, and were on feed for 62 days. The lambs used in these experiments originated in the northwestern area of the United States and all were wethers. All lambs were vaccinated for enterotoxemia prior to the start of the experiments. Carcass grades and dressing percent are available only on a limited number of the individually fed animals. This information is available on all group-fed animals; however, it is on a ration basis rather than on an individual lamb basis. Measurement on the size of the bulbourethral gland was made in 30 of the individually fed lambs.

For the individually fed lambs an analysis of variance of the average daily gains and the average daily feed consumption data including the sum of squares among rations attributed to linear regression was computed for each experiment. With the group-fed lambs an analysis of variance was computed of the individual lamb average daily gains in each experiment. The pens of twenty lambs each were considered to be the experimental units and not the individual lambs.

Results

Weight Gains and Feed Consumption

The weight gains and feed consumption of the individually fed lambs are presented in table 2. At levels below 600 mcg. stilbestrol per lb. of ration or about 2.0 mg. per lamb per day there were no consistant increases in weight gain. At levels of 600 mcg. or higher weight gains were increased. However, only in Experiment 4 was the increase in weight gains significant ($P = .05$). In trial four, weight gains were nearly identical for the two groups of lambs receiving the 600 mcg. level of stilbestrol. Feed consumption was not consistantly increased by the addition of stilbestrol to the ration. The data from the individually fed lambs suggest that weight gains in lambs can be increased by the addition of 600–1200 mcg. of stilbestrol per lb. of ration.

Results of the group-fed lambs are presented in table 3. Two of the group-fed lambs died during the experiment and a limited number were removed due to their failure to eat the ration. This condition did not appear to be due to treatment.

In neither of the experiments in which the lambs were group-fed were the mean differences of gains among rations statistically significant using the among pen estimate of experimental error. Research in progress at the Statistical Laboratory, Iowa State College, on pooling

TABLE 2. WEIGHT GAINS, FEED CONSUMPTION AND DIAMETER OF BULBO-URETHRAL GLANDS OF INDIVIDUALLY FED LAMBS RECEIVING DIETHYLSTILBESTROL

Experiment No.	Days fed	Micrograms diethylstilbestrol per lb. of ration						600 mcg. plus fat	Standard error of ration means
		0	150	300	600	900	1200		
		Mean average daily gain, lb.							
1	84	.398	.428						.053
2	57	.480	.478	.366	.583				.050
3	56	.382		.408	.432	.395	.462		.044
4	67	.346		.433	.462	.509		.457	.046
		Mean average daily feed consumption, lb.							
1		3.84	3.44						0.26
2		4.34	3.80	3.30	4.40				0.33
3		4.11		3.60	3.83	3.68	3.91		0.24
4		3.79		4.02	3.56	4.18		3.92	0.15
Diameter of gland, mm.		7.0(10)[a]	10.0(4)		13.0(12)	12.0(4)			

[a] Values in parenthesis represents number of lambs measured.

TABLE 3. WEIGHT GAINS, FEED CONSUMPTION AND ANALYSES OF GROUP-FED LAMBS RECEIVING DIETHYLSTILBESTROL—62 Days

		Micrograms diethylstilbestrol per lb. of ration					
		Experiment 1			Experiment 2		
Description	Rep.	0	600	1200	0	600	1200
No. lambs	1	18	19	20	18	17	19
	2	20	19	19	18	20	18
Av. daily gain, lb.	1	.353	.379	.350	.282	.347	.324
	2	.338	.417	.345	.308	.436	.413
Av. daily feed consumption, lb.	1	3.15	3.15	3.11	2.93	2.92	2.57
	2	3.09	3.03	3.05	2.91	3.06	3.13

Analysis of Variance of Average Daily Gains

Source of Variation	d.f.	M.S.	F.	d.f.	M.S.	F.
Replicates	1	.0011		1	.1366	
Rations	2	.0350	4.22	2	.1020	7.50
Experimental error	2	.0083		2	.0136	
Lambs/pens	109	.0107		104	.0124	

Experiments 1 and 2 combined

Experiments	1	.0075	
Reps./experiments	2	.0688	
Rations	2	.1107	10.16 *
Rations × experiments	2	.0263	
Pooled experimental error	4	.0109	
Lambs/pens	213	.0115	

* Significant at P = .05.

mean squares based on a preliminary test of significance indicates that the among pen error mean square should not be pooled with the within pen mean square for an estimate of experimental error in either experiment (Bancroft *et al.*, 1955). When these data for the two experiments are combined the mean differences in gains among rations are significant at the 5 percent level.

In the case of the first group feeding trial the lambs which were supplemented with 1.8 mg. of stilbestrol per lamb per day made daily gains of 0.05 lb. more than the controls. However, when the level of stilbestrol feeding was increased to 3.6 mg. per lamb per day the rate of gains were not increased over those of the controls. Feed consumption was not increased by the stilbestrol in the first group feeding experiment. In the case of the second group feeding experiment the addition of 600 mcg. of stilbestrol per lb. of feed increased rates of gains by 0.10 lb. over the control group. The intake of stilbestrol by this group

TABLE 4. GRADE, DRESSING PERCENT, AND COOLER SHRINK OF INDIVIDUALLY FED LAMBS RECEIVING DIETHYLSTILBESTROL

	Micrograms diethylstilbestrol per lb. of ration					
	0	150	300	600	600 [c]	900
Experiment 2						
Grade [a]	4	3.5	3.0	3.5		
Dressing percent	45.7	46.2	44.7	45.6		
Experiment 4						
Grade	4.3 [b]			3.8	5.2	4.8
Dressing percent	49.6			49.0	51.7	49.8
Cooler shrink percent (24 hours)	2.8			2.8	2.4	2.8

[a] Numerical value of 4 is equivalent to low choice.
[b] Only 3 lambs in this treatment level as compared with 4 for all other groups.
[c] Three percent fat was added to the rations of the lambs in this group.

of lambs was 1.9 mg. per lamb per day. When the level was increased to 1200 mcg. per lb. of feed, rates of gains were decreased below that of the 600 mcg. level. In this case the intake of stilbestrol was 3.6 mg. per lamb per day. There was a slight decrease in feed intake in this ration as compared with the lambs receiving the low level of stilbestrol. In both of the group-fed trials the higher level of stilbestrol appeared to reduce gains from those obtained with the lower level.

Carcass Data

Carcass data are available on 24 of the individually fed animals. These data by experiments are shown in table 4. Data from Experi-

ment 2 suggests that carcass grades were lowered due to addition of the stilbestrol. Dressing percent based on chilled carcass weights was not affected. In Experiment 4 the carcass grades, dressing percent and cooler shrink were apparently not affected by the stilbestrol. In this experiment the addition of 3 percent fat to a ration containing 600 mcg. stilbestrol per lb. of ration suggests that carcass quality was improved over the same ration containing no added fat. In this experiment the feeding of 900 mcg. (approx. 4 mg. per lamb per day) apparently did not have an injurious effect on carcass quality.

The carcass data for the group-fed lambs are presented in table 5.

TABLE 5. DRESSING PERCENT AND GRADE OF GROUP-FED LAMBS RECEIVING DIETHYLSTILBESTROL

	Micrograms diethylstilbestrol per lb. of ration					
	Experiment 1			Experiment 2		
	0	600	1200	0	600	1200
Number of lambs	37	38	39	35	37	37
Dressing percent	48.5	48.6	48.6	49.0	48.2	48.5
Grade						
Choice	18	20	9	28	24	16
Good	19	14	29	7	13	19
Utility		4	1			2

The distribution of carcass grades differs significantly among rations in both experiments as indicated by a chi-square test of independence. However, this test did not separate treatment level. In group feeding Experiment 1, the stilbestrol had no effect upon dressing percent. The high level of 3.6 mg. stilbestrol per lamb per day reduced carcass grade considerably. The low level of 1.8 mg. per lamb per day had a questionable effect upon carcass quality. In this case the number of choice lambs in the stilbestrol-fed lot was greater than in the control group, but there were four utility carcasses in the lot. In the second group feeding experiment dressing percent was somewhat lower in the stilbestrol-fed lambs when compared with the controls. There was also a reduction in grade as the level of stilbestrol was increased and this reduction was more evident at the high level. In both of the group-fed experiments the carcasses from the lambs receiving the low-level of stilbestrol compared very favorably with those of the controls in both grade and appearance. It should be pointed out that dressing percent in the group-fed lambs was based upon warm carcass weights which were shrunk 1.75 percent

to obtain chilled carcass weights. It is interesting to note that in the group-fed lambs the addition of fat appeared to improve carcass grade. This was also observed with the individually fed lambs.

Bulbo-Urethral Gland Measurements

Bulbo-urethral gland measurements were taken on 30 of the individually fed lambs. These data are presented in table 2. Lambs from different experiments have been grouped. Only in one instance did the ration vary and that was with lambs fed the 600 mcg. level that had fat added to the ration. In this instance the added fat appeared to decrease the size of the gland. It is apparent that the size of the bulbo-urethral gland was increased by the addition of stilbestrol to the ration ($P = .05$). It should be pointed out that no difficulty was noted in these individually fed lambs due to the enlargement of the gland.

Feed lot observations

Observations of the activity of the lambs in the feed lot did not reveal differences between the treated and non-treated lambs. Mounting or similar actions were not observed. However, close examinations of the lambs did reveal some differences. With the lambs that received approximately 2 mg. or more of stilbestrol per lamb per day there was an enlargement of the prepuce. No measurements were made but in general the size of the prepuce appeared largest with the highest level of stilbestrol. Examination of the prepuce with lambs fed high levels of stilbestrol revealed that they were ulcerated. Several lambs receiving high levels of stilbestrol (3.6 mg. or higher per lamb per day) constantly dripped urine and were not observed to urinate at regular intervals. This constant urination may partially explain the ulceration of the prepuce. This constant dripping of urine cannot be explained at the present time but may be due to an enlargement of the bulbo-urethral gland resulting in a partial closure of the urethra. With lambs receiving the high levels of stilbestrol (3.6 mg. or higher per day) an edema of the anal area was noted with some lambs.

The higher levels of stilbestrol caused some mammary development of the wether lambs but this condition was not marked.

Discussion

The feeding of approximately 2 mg. of stilbestrol per lamb per day in connection with a lamb fattening ration increased weight as much as 30 percent in one group feeding trial and 14 percent in a second trial.

When all individual feeding trials and the group feeding trials are considered the increase in weight gains due to stilbestrol when fed at about 2 mg. per lamb per day was approximately 22 percent. At this level, stilbestrol had little or no effect upon carcass grade; however, at higher levels (3.6 mg. per lamb per day) there was a reduction in carcass grades. Feed consumption was not consistently increased by the addition of stilbestrol to the rations of fattening lambs. The growth and carcass data presented here suggest that feeding of approximately 2 mg. of stilbestrol per lamb per day resulted in an increased production in fattening lambs.

The severe toxicity symptoms frequently noted with stilbestrol implanted lambs were not observed with the lambs reported in these experiments. However, with the higher levels some changes in the external appearance of the lamb could be noted such as enlarged prepuce, anal edema and mammary development. These conditions have been reported for stilbestrol implanted lambs (Jordan, 1953; Bell *et al.*, 1953).

The mechanism by which orally administered stilbestrol exerts its action in lambs is not known at the present time. In the stilbestrol implanted lamb the absorbed stilbestrol would first presumably appear in the systemic circulation before being detoxified by the liver. It has been shown with rats (Hanahan *et al.*, 1953) that orally administered stilbestrol is absorbed by the portal system, detoxified in the liver and excreted into the intestinal tract via the bile as a glucoronide. This glucoronide is only weakly active. If this mechanism occurs in the lamb little or no stilbestrol may appear in the systemic circulation. It may be that the site of action of stilbestrol is in the liver.

Summary

The feeding of approximately 2 mg. of diethylstilbestrol (stilbestrol) per wether lamb per day in connection with a fattening ration increased rates of gains approximately 22 percent over the controls. No consistant increase in feed consumption was noted with stilbestrol-fed lambs. At this level of supplementation stilbestrol had little or no effect upon carcass quality; however, at higher levels there was an apparent decrease in carcass quality. Higher levels of supplementation (3.6 mg. per lamb per day) in group feeding trials failed to promote as satisfactory rates of gain as did the lower levels. Close examination of supplemented lambs revealed certain changes in external appearance similar to those noted with stilbestrol implanted lambs. The changes were enlargement of the

prepuce, mammary development and edema of the anal area. The degree of these conditions appeared to be associated with level of stilbestrol feeding. The severe toxicity symptoms noted with stilbestrol implanted lambs were not observed by oral administration of stilbestrol in these experiments.

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THE EFFECT OF LEVEL OF FEEDING ON THE REPRODUCTIVE CAPACITY OF THE EWE [1]

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THE effect of feed level on reproductive activity has probably been better recognized for sheep than for other species of farm mammals (Marshall, 1903, 1922; Marshall and Potts, 1924). Presumably its effect may be exerted through the growth of the reproductive tract, the activity of the ovaries in producing ova (perhaps both quantitatively and qualitatively), and the intra-uterine environment. The latter may affect embryo survival and the growth capacity of the fetuses through the development of the placentae and the transfer of nutrients between the maternal and fetal circulation.

The present report covers an investigation of the effect of high and medium planes of feeding on the development and functional activity of some of the reproductive organs in the ewe, particularly the ovaries, the uteri, and the fetal membranes.

Materials and Methods

A group of 80 native ewes (mixture of Shropshire, Hampshire, Oxford) was used for this study in each of two years, 1953 and 1954. A random half was fed on 2 lb. each daily of a grain mixture (5 parts ground corn, 3 parts whole oats, 1 part bran, and 1 part linseed meal) and alfalfa-brome-grass mixed hay of No. 2 grade (replaced by sweet clover pasture for one month during the summer); the rest of the ewes were fed only on the hay (or pasture). These two groups were started on feed in January of each year when the ewes were short yearlings, and continued until the time of slaughter in late summer or early fall. Ewes when put on feed were in medium condition and weighed on the average about 80 lb. The ewes were bred to rams that were used in another experiment to study the effect of feed level, shearing, and the ambient temperature on their body temperature and fertility. The rams were divided into four treatment-groups: group one, full-fed roughage, plus grain, and sheared in April and at monthly intervals thereafter; group two, full-fed rough-

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age, plus grain, and sheared once in April; group three, full-fed on roughage only and sheared at monthly intervals starting in April; and group four, full-fed on roughage only and sheared once in April. Each ram in each group was bred to at least two ewes of the group fed on grain-plus-roughage and to two ewes fed on roughage-only. A total of 118 ewes was slaughtered 3 days post-coitum in both years, 60 of them having been fed on roughage-plus-grain and 58 on roughage-only. Forty-two ewes were slaughtered 40 days post-coitum; 19 of them were fed on roughage-plus-grain and 23 on roughage-only. Most of the ewes were slaughtered in the University Meat Laboratory. A few ewes were killed at a local packing plant. Ewes on the high level of feeding (grain and roughage) averaged approximately 134 lb. in weight at slaughter and their finish graded choice + to prime. On the other hand, ewes on medium level of feeding (roughage-only) weighed on the average 95 lb. and their average finish grade was good.

This study includes observations on fertilization rate, normality of ova, measurements and weights of structures and organs of the reproductive tract as well as the weights of embryos and embryonic membranes for those ewes killed 40 days post-coitum.

Data obtained in each year were analyzed statistically for testing the significance of the difference in the size, weight, and number of structures or organs of the ewes and their embryos as caused by litter size (no. embryos per ewe) and/or by feed level. When the trends of the mentioned observations were in the same direction in the two years, data were pooled for statistical analysis especially because of the limited number of observations in each of the two years. In such case only the significance over the two years was indicated in the results mentioned below. Mean values for each year are presented for the 3-day ewes but only means for the pooled two years' data are presented on the smaller number of 40-day ewes.

Results and Discussion

Ewes Examined Three Days Post-Coitum

Size of the Ovaries, Average Size of Corpora Lutea, Size and Number of Corpora Albicantia, Average Diameter of the Largest Follicle, and the Number of Follicles on the Ovaries. Level of feeding affected significantly ($P < .01$) the size of the ovaries in which corpora lutea were present (table 1). This effect is likely due to the higher ovulation rate and consequently greater number of corpora lutea on the ovaries of ewes fed a supplement of grain mixture. A significant effect for level of feed-

ing on the size of ovaries having no corpora lutea was also noted. Level of feeding had no significant effect on the size of corpora lutea, or the size of corpora albicantia 2 mm. or more in diameter.

The proportion of ewes having more than one corpus albicans, 2 mm. or more in diameter, per ewe, was significantly greater for those fed on roughage-plus-grain (table 1). This significant difference in the number of corpora albicantia reflects the effect of the two feed levels on ovula-

TABLE 1. EFFECT OF LEVEL OF FEEDING ON THE SIZE OF OVARIES AND THE STRUCTURES ON THEM (3 DAYS POST-COITUM)

Observation	Year	Rough-age-plus-grain	Rough-age-only	Significance of feed level comparison
		Average [b]	Average [c]	
Size of ovaries [a] (c.l. absent)	1953	1644	1325	**
	1954	1465	1113	
Size of ovaries [a] (c.l. present)	1953	1805	1424	**
	1954	1773	1574	
Size of corpora lutea [a]	1953	212	233	
	1954	313	367	
Size of corpora albicantia [a]	1953	54	74	
	1954	114	123	
Number of corpora albicantia per ewe	1953	1.39	1.17	*
	1954	1.38	1.18	
Diameter of largest follicle (mm.)	1953	6.6	5.5	**
	1954	6.4	5.3	
No. follicles (2 mm. or more in diameter) per ewe	1953	5.7	4.8	
	1954	5.6	5.0	

[a] Product of three dimensions in mm.
[b] Results based on 28 ewes in 1953, and 32 in 1954.
[c] Results based on 31 ewes in 1953, and 27 in 1954.
* P less than 0.05.
** P less than 0.01.

tion rate. Ewes fed on grain-plus-roughage had significantly larger follicles which undoubtedly contributed to the greater size of ovary noted above. The ewes on the higher level of feeding also had insignificantly greater number of follicles 2 mm. or more in diameter.

Size of the Uteri and the Normality of the Reproductive Organs. The average size of the uterine horns was represented by the products of two measurements; one measurement was the largest diameter of the uterine horn, the other was the length from the external bifurcation to the tubo-uterine junction of the "straightened" horn with the broad ligament cut away. Uterine horns of ewes fed on grain-plus-roughage were signifi-

TABLE 2. EFFECT OF LEVEL OF FEEDING ON THE SIZE OF UTERINE HORNS OF EWES (3 DAYS POST-COITUM)

Year	Roughage-plus-grain		Roughage-only		Significance of feed level comparison
	No. of ewes	Av. Size	No. of ewes	Av. size	
1953	28	1713	31	1555	
1954	32	1719	27	1528	**

** P less than .01.

cantly ($P < .01$) larger than horns of ewes fed on roughage-only (table 2). The effect of higher level of feeding on the development of the reproductive tract of ewes, represented by its length, was shown by Phillips *et al.* (1945) and was shown by Roux (1936) as represented by the uterus weight.

Comparing the size of the right and left horn, no significant difference was found. None of the genital tracts of ewes fed on grain-plus-roughage showed any evidence of abnormality. Four genital tracts of ewes fed on roughage-only had salpingitis and hydrosalpinx of various degrees.

Ovulation Rate, Percent of Ova Lost and Ova Recovered, Abnormal Ova, and Fertilization Rate. Ovulation rate (table 3) was significantly ($P < .01$) higher for ewes fed on grain-plus-roughage. Clark (1934) found that the ovulation rate for flushed ewes was higher than for the

TABLE 3. OVULATION RATE, OVA RECOVERED AND PERCENTAGE OF OVA RECOVERED, FERTILIZATION RATE, AND PERCENT OF ABNORMAL OVA OF EWES ON 2 LEVELS OF FEEDING KILLED 3 DAYS POST-COITUM

Comparison	Year	Roughage-plus-grain	Roughage-only	Significance of feed level comparison
Number of ewes	1953	28	31	
	1954	32	27	
Av. no. ovulations per ewe	1953	1.81	1.27	**
	1954	1.66	1.04	
Percent c.l. represented by recovered ova	1953	87	97	
	1954	94	86	
Percent recovered ova that were fertilized	1953	66	59	
	1954	83	65	
Av. no. fertilized ova per ewe	1953	1.04	.73	
	1954	1.31	.58	
Percent recovered ova that were abnormal	1953	7.3	8.0	
	1954	6.5	12.5	

** P less than .01

unflushed. He concluded that a rising plane of nutrition could have a beneficial influence provided that ewes are in a relatively thin condition in the beginning. McKenzie and Terrill (1937) showed that by lowering the plane of nutrition, the number of ova shed at ovulation was reduced. Darlow (1942) showed that there was a significantly greater number of fertile and twin producing animals in a group of medium-wooled Wisconsin ewes fed on a very good ration compared with those fed on a very poor ration. Another part of the same study made at Oklahoma (on a group of medium and fine-wooled ewes), however, showed no significant difference in the number of multiple births but a significantly greater number of barren ewes in the group fed on very poor ration. Wallace (1954) also found that the high level of feeding increased ovulation rates of ewes.

There was no significant difference between the two levels of feeding in the percentage of ova lost (table 3). The loss of ova could be due to several factors, i.e., ova trapped in the rupturing follicles, ova lost in the body cavity, ova hard to detect under the microscope especially when they are broken or if only on empty zona pellucida remains, and ova lost during the process of flushing of the oviducts especially in the case of hydrosalpinx.

The fetilization rate for ewes fed on grain-plus-hay was insignificantly higher than for ewes fed on hay-only (table 3) in each year.

It was a matter of judgment to distinguish between a normal cleaved ovum and an abnormal one which presumably would be unable to survive and also between uncleaved ova where fertilization had failed because of an egg defect and unfertilized ova where the sperm had been at fault. Uncleaved ova with no zona pelludica (or not seen), empty normal or broken zona pellucida, small ova with a shrunken darker cytoplasm, and ova fragmented rather than cleaved are among the ova considered abnormal in the present study. Table 3 shows the percentage of recovered ova that were abnormal. Two of the fertilized ova studied had no visible sperm in the zona pellucida. The number of sperm seen in the zona pellucida of fertilized ova varied from none to several dozen. In nine out of twelve unfertilized; no sperms were seen in the zona pellucida. In three unfertilized ova, the number of sperms seen in the zona pellucida varied from one to several.

Ewes Examined 40 Days Post-Coitum

Averaged Size of Corpora Lutea, Average Diameter of the Largest Follicle on Both Ovaries of Each Ewe, and the Number of Follicles on the Two Ovaries. The average size of corpora lutea on the ovaries of

TABLE 4. OBSERVATIONS OBTAINED IN 1953 AND 1954 ON EWES KILLED 40 DAYS POST-COITUM

Observation	Roughage-plus-grain		Roughage-only		Significance of comparison
	No. ewes	Av.	No. ewes	Av.	
Size of c.l.[a] (1 c.l./ewe)	9	1282	18	1346	No. c.l.**
Size of c.l.[a] (more than one c.l. per ewe)	9	1041	5	885	
No. follicles per ewe	18	12.7	23	8.8	Feed level **
Diameter of follicle (mm)	18	6.4	23	6.6	
Embryos per ewe in 1953	20	.7	20	.5	
Embryos per ewe in 1954	19	.4	19	.7	
Embryonic survival % (1953)	20	57.5	20	66.8	Feed level **
Embryonic survival % (1954)	19	26.9	19	100.9	and years **
Size of pregnant horn [b] (one embryo per ewe)	13	5822	20	5083	Litter size **
Size of pregnant horn [b] (two embryos per ewe)	5	6979	3	7592	
Weight of pregnant horn minus wt. of cotyledons [c] (one embryo per ewe)	13	32.4	20	28.3	Feed level * &
Weight of pregnant horn minus wt. of cotyledons [c] (two embryos per ewe)	5	41.7	3	37.7	Litter size **
Weight of cotyledons in the pregnant horn [c] (one embryo per ewe)	13	8.7	20	8.6	
Weight of cotyledons in the pregnant horn [c] (two embryos per ewe)	5	11.1	3	6.7	
Size of non-pregnant horn [b]	13	4606	20	3624	Feed level *
Weight of non-pregnant horn minus cotyledons [c]	13	25.4	20	22.4	
Size of the largest cotyledon [b] (non-preg. horn)	13	109.8	20	90.2	
Weight of the cotyledons [c] (non-preg. horn)	13	3.7	20	3.6	
Crown-rump length (mm; one embryo per ewe)	13	41.3	19[d]	42.8	
Crown-rump (mm; two embryos per ewe)	5	41.2	3	38.3	
Weight of embryos [c] (1 embryo per ewe)	13	5.3	19	5.3	
Weight of embryos [c] (2 embryos per ewe)	5	5.1	3	5.0	
Amnion weight [c] (one embryo per ewe)	13	1.7	19	1.8	
Amnion weight [c] (two embryos per ewe)	5	1.4	3	1.7	
Chorion weight [c] (one embryo per ewe)	13	52.6	19	41.4	Feed level * &
Chorion weight [c] (two embryos per ewe)	5	42.1	3	21.7	Litter size *
Amnionic fluid weight [c] (one embryo per ewe)	13	26.2	19	27.1	
Amnionic fluid weight [c] (two embryos per ewe)	5	24.9	3	21.3	
Chorionic fluid weight [c] (one embryo per ewe)	13	53.3	19	46.6	
Chorionic fluid weight [c] (two embryos per ewe)	5	37.2	3	56.8	
Size of amnionic vesicle [b] (one embryo per ewe)	13	2642	19	2819	Litter size *
Size of amnionic vesicle [b] (two embryos per ewe)	5	2525	3	2256	

* P less than .05.
** P less than .01.
[a] Products of 3 dimensions in mm.
[b] Products of 2 dimensions in mm.
[c] Grams.
[d] One ewe was excluded from this group in all considerations of the embryo because of abnormal hemorrhagic condition of embryo.

ewes fed on grain-plus-roughage was not significantly larger than for ewes fed on roughage-only (table 4). Ewes with multiple ovulations had significantly ($P < .01$) smaller corpora lutea than those with single ovulations. There was a significant difference ($P < .01$) between ewes on the two levels of feeding in the number of follicles 2 mm. or more in diameter but not in the diameter of the largest follicles which were present on the ovaries.

Number of Corpora Lutea per Ewe, Number of Embryos per Ewe, and the Embryonic Survival Rate. The number of corpora lutea per ewe for the animals fed on grain-plus-roughage was 1.6 and on roughage-only was 1.2 with a difference of 0.4 corpus luteum per ewe. The embryonic survival rate was calculated using the formula:

$$\text{Embryo survival} = \frac{\text{Av. no. normal embryos per ewe bred (40 days group)}}{\text{Av. no. normal embryos per ewe bred (3 days group)}} \times 100.$$

Embryonic survival rate was lower in the ewes on the higher level of feeding by 9.26 percent in 1953, and by 74.03 percent in 1954 than in ewes on the medium level of feeding. The differences in the embryonic survival rates of the two groups of ewes were significant ($P < .01$) only in 1954. There was a significant difference ($P < .01$) between years in embryo survival as tested by analysis of chi-square by the method of Rao (1952), a method of analysis which takes into consideration unequal subclass numbers. The results obtained here suggest that ewes as well as gilts (Robertson *et al.*, 1951; Christian and Nofziger, 1952; and Self *et al.*, 1953) have higher ovulation rates and lower embryonic survival rates when fed on high level of feeding than when fed on a medium level. More work is needed to reveal the nature of the relationship between levels of feeding and embryo survival. Combining the effect of higher feed level on the higher ovulation rate and higher fertilization rate with the effect of the moderate feed level after breeding may be useful in increasing the reproductive capacity of sheep.

The Size and Weight of the Uterine Horns, and the Weight of Cotyledons. Litter size affected significantly the size of the pregnant horns (one embryo per horn in each case) but feed level did not have a significant effect (table 4). The weight of the pregnant horns (cotyledons trimmed off) was affected significantly ($P < .01$) by the size of litter, and by level of feeding ($P < .05$). The significant effect of feed level on the weight of pregnant horns and not on their size may possibly be due to an increase in the thickness of the uterus. There was no significant effect for either level of feeding or the size of litter on the weight of the cotyledons removed from the pregnant horns. A significant ($P < .05$)

interaction between level of feeding and size of litter on weight of cotyledons was shown in 1953 only.

Level of feeding had a significant ($P < .05$) effect on the size of non-pregnant horn (table 4). No significant effect was found for level of feeding on the weight of the non-pregnant horn (cotyledons trimmed off), the weight of the cotyledons or the size of the largest cotyledon.

Embryos, Membranes and Fluids. No significant effect was shown (table 4) for level of feeding or litter size on the crown-rump length or weight of embryos 40 days old. Single embryos had significantly ($P < .05$) heavier chorions than twins. Ewes fed on roughage-plus-grain also had heavier chorions, but no significant effect was shown for either the litter size or the level of feeding on the amnion weight, amnionic fluid weight, or chorionic fluid weight. The size of the amnionic vesicle was larger when only one embryo was present per ewe than when the ewe had two amnionic vesicles.

Migration of Embryos in the Uterus. Migration of embryos from one uterine horn to another occurred for 12 percent of the embryos. This percentage represents the least possible since some embryos may have migrated and then returned, or have been resorbed after migration, or two embryos may have exchanged places in the two horns. The causes of embryo migration are not understood; however, it may be due to the spacing of the embryos which is actually involved when two or more embryos originate on one side and none on the other.

One Case of Suspected Identical Twins. One of the ewes killed 40 days post-coitum had one corpus luteum on the right ovary and none on the left. Two embryos were found; once in each horn, and each embryo had separate embryonic membranes. The two chorions were externally fused and not different from what was noted in the case of fraternal twins. There was no way of determining whether they were one-egg twins or whether two eggs were produced from one follicle. Henning (1937) described a double sheep pregnancy with a single corpus luteum among 675 fetuses studied. He concluded from a study of the fetuses and their membranes that there was strong evidence for the pair being monozygotic twins.

General Discussion

Roux (1936) and Phillips *et al.* (1945) showed that feed level affected the size and weight of the reproductive tract of ewes. The present study showed that feeding ewes on a higher level caused a significant increase in the number of corpora lutea and in the size of the largest follicles as observed in the 3-day ewes and in the number of follicles as observed in

the 40-day ewes. The data also showed that uterine horns of ewes fed on the higher feed level were larger than horns of ewes fed on roughage only. The greater ovarian and uterine development is presumably a result of increased gonadotrophic activity of the anterior pituitary gland and, in turn, increased endocrine activity of the ovary. Direct evidence for these assumptions apparently is not available. Further it is not known whether equal endocrine activity in the grain-fed individuals would accomplish greater stimulation of the ovaries or of the uterus than in the roughage-only ewes.

Wallace (1946, 1948) showed that there were no marked differences in weight of fetuses, carried by Suffolk ewes fed on high and low levels from the 28th day of pregnancy, during the first 91 days of pregnancy. Further, the ewes on a high level of feeding up to 91 days followed by a low level diet till 144 days gave birth to smaller lambs than those on a low level diet up to 91 days followed by a high level diet to 144 days. Winters and Feuffel (1936) showed that the weight of the sheep fetus at 90 days is approximately 500 gm. and only after this age does a tremendous increase in the weight of the fetus occur. The interpretation by Barcroft (1946) of the observations of Winters and Feuffel and of Wallace was that as long as the fetus remains small, the mother is able to supply enough nourishment to meet the demands of her offspring whether twins or singlets. The present results showed that the reduction in the feed level during the first 40 days of pregnancy did not affect fetal development significantly, neither did it affect significantly the weights of the amnion or of the fetal fluids.The data also failed to show an effect of litter size on the same variables. Both feed level and litter size, however, did affect chorion weight. It has been shown for swine (Baker, 1954) that the dependence of fetal weight on fetal membrane weight increases markedly between the 25th and 70th day of gestation. The present study would indicate that the chorion in sheep is affected by differences in nutritive plane or by competition earlier than is the embryo. If variability in fetal weight in the sheep increases in its dependence on membrane weight with advance of gestation, the membrane effect at 40 days presumably would be expressed in terms of variability in fetal weight later in gestation.

Summary

A study was made, in 1953 and 1954, of the effect of feed level on the reproductive capacity of yearling ewes. Ewes (short-yearlings) were divided at random into two groups; one group was fed on roughage-plus-grain, and the other was fed on roughage-only beginning in January

of both years. The feeding regimen was continued until the time of slaughter in the fall. Half of the ewes on each feed level was slaughtered 3 days post-coitum, and the other half at 40 days post-coitum (except some ewes that showed a second heat after breeding and were rebred and killed 3 days later). The study includes observations on ovulation rate, fertilization rate, normality of the ova as well as measurements and weights of structures and organs of the reproductive tract, and weights of embryos, embryonic membranes and fluids.

The results were as follows:

1. Ewes on the high level of feeding had significantly higher ovulation rate, larger follicles, and higher number of follicles 2 mm. or more in diameter.

2. Fertilization rate was higher, though not significantly so, for the ewes on the higher level of feeding.

3. The embryonic survival rate was lower in the ewes on the higher level of feeding. The difference in embryonic survival rate between the two groups of ewes was highly significant in 1954. Also there was a significant interaction between year and level of feeding on embryo survival.

4. Ewes on the higher level of feeding had significantly larger uteri (slaughtered 3 days post-coitum).

5. The weight of the 40-day pregnant horn of ewes (cotyledons trimmed off) was significantly affected by feed level. Also the non-pregnant horns of ewes fed on grain-plus-roughage were significantly larger than for ewes fed on roughage-only.

6. Level of feeding did not have a significant effect on weight of cotyledons in the pregnant uterine horn, but a significant interaction between feed level and size of litter on the weight of cotyledons was shown in 1953.

7. Feed level had no significant effect on crown-rump length of 40-day embryos, weight of embryos, amnion weight, amnionic fluid weight, chorionic fluid weight, and size of amnionic vesicle. There was a significant effect for feed level on weight of chorion.

8. Comparing the pregnant horns only, it was shown that ewes which had twin embryos (each in separate horn) had significantly larger and heavier horns (cotyledons removed) than pregnant horns of ewes having single embryos.

9. Crown-rump length of embryos, weight of embryos, weight of amnions, weight of chorions, weight of amnionic fluid, and size of amnionic vesicle were greater for singles than for twins under both levels

of feeding, but differences only in chorion weight and in size of amnionic vesicle were statistically significant.

10. Migration from one uterine horn to the other occurred for at least 12 percent of the embryos.

11. One case of suspected identical twins was observed.

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THE OCCURRENCE OF HISTAMINE AND TYRAMINE IN RUMEN INGESTA OF EXPERIMENTALLY OVER-FED SHEEP

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INVESTIGATIONS by Dougherty *et al.* (1949, 1952) have shown the presence of toxic material in rumen ingesta of sheep suffering from acute indigestion. When the liquid part of the rumen contents of sick sheep was injected intravenously into an anesthetized dog or sheep, a pronounced and prolonged drop in blood pressure was noted as well as a decrease in rumen activity in the sheep. Attempts to establish the chemical nature of the toxic substances were unsuccessful (Dougherty, 1952).

It has been well established that intravenous injection of histamine results in rumen paralysis (Dougherty, 1942a; Clark, 1950). Dougherty (1942b) has reported the occurrence of histamine in the rumen ingesta of three steers which had died of bloat. Rodwell (1953) has isolated 8 species of Lactobacilli from the rumen ingesta of an over-fed sheep, which have the ability to decarboxylate histidine to form histamine. The purpose of this paper is to show the occurrence of histamine and tyramine in rumen ingesta of experimentally over-fed sheep and that normal sheep ingesta is practically free of histamine.

Experimental

Acute indigestion was produced by over-feeding rumen fistulated sheep with four pounds of new wheat or cracked corn as previously described by Dougherty (1952). Samples of rumen ingesta were removed at various intervals of time for chemical and physiological studies and for comparison with ingesta obtained from sheep on a good hay ration.

Approximately 200 ml. of rumen ingesta were centrifuged at 2500 r.p.m. and the supernatant liquid removed by decantation. One hundred ml. of the supernatant were dialyzed against 400 ml. of distilled water for 48 hours at room temperature. During this period, the solution was

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stirred with a magnetic stirrer and changed every 12 hours. The dialysate was then lyophilized to dryness, the residue was dissolved in 100 ml. of distilled water, and a 0.5 ml. aliquot was subjected to the cotton acid succinate (CAS) method of McIntire *et al.* (1947) for the removal of histamine from biological fluids. After diluting the sample to 4.5 ml. with glass distilled water, the salt mixture of sodium sulfate and sodium phosphate was added and the solution extracted with n-butanol. The extract was passed over a CAS column which was then washed with 3 ml. of 95 percent ethanol followed by 3 ml. of glass distilled water. The column was eluted with 1 ml. of 0.4 N HCl followed by 1 ml. of water. The eluate was taken to dryness on a steam bath, the residue dissolved in 0.1 ml. of glass distilled water and the solution

TABLE 1. COMPARISON OF R_f VALUES IN DIFFERENT SOLVENTS

Developed spot	Solvent system				
	A	B	C	D	E
Histamine dihydrochloride	.11	.27	.57	.23	.20
Red spot	.09	.27	.58	.23	.12
Tyramine hydrochloride	.50[a]	.74	.79	.66	.78
Orange spot	.50[a]	.74	.79	.66	.74

A. t-Butanol 0.70, Formic acid 0.15, water 0.15 (Mehler *et al.*, 1952).
B. Lutidine 0.55, Ethanol 0.20, water 0.25, Diethyl amine 0.01 (Mehler *et al.*, 1952).
C. n-Propanol 0.75, 0.2 N Ammonium Hydroxide 0.25 (Ames *et al.*, 1952).
D. n-Propanol 0.75, 1 N Acetic acid 0.25 (Ames *et al.*, 1952).
E. Butanol, Acetic acid, water (Block *et al.*, 1952).

[a] Spot streaks.

was chromatogrammed on Whatman No. 1 filter paper. The ascending technique was employed to develop the chromatograms using several different solvents, see table 1 (Ames *et al.*, 1952; Mehler *et al.*, 1952; Block *et al.*, 1952). After the developed chromatograms were dried, they were sprayed with diazotized sulfanilic acid and sodium carbonate to develop the spots (Ames *et al.*, 1952).

Results and Discussion

Non-Dialyzable Fraction

The intravenous injection of 0.5 ml. of the non-dialyzable solution obtained from either over-fed or well sheep resulted in a pronounced gradual lowering of the blood pressure after about 20 seconds. The blood pressure remained low for 30 to 60 minutes, after which it returned to normal. Upon subsequent injections, the animal was found to be rela-

tively refractive and remained so for a period of at least several days. Since this effect is similar to that produced by the injection of polyvinylpyrrolidone (PVP) (Loubatiéres *et al.*, 1948; Clark *et al.*, 1953; Benet *et al.*, 1948; Halpern *et al.*, 1953), it was of interest to determine if PVP would make the animal refractive to injections of the non-dialyzable fraction.[2] The injection of 0.5 ml. of a 25 percent solution of PVP did not make the animal refractive toward a subsequent injection of 0.5 ml. of the non-dialyzable fraction obtained from either the overfed or the well sheep. Also the non-dialyzable fractions did not protect the animal against the effect of PVP. A previous injection of 7.5 ml. of a 2 percent solution of pyribenzamine protected the dog against subsequent injections of the non-dialyzable fractions. This is similar to the response obtained with PVP as shown by Besse *et al.*, 1953. It is possible that a substance in the non-dialyzable fractions may act as a histamine liberator as has been suggested for the action of PVP (Halpern *et al.*, 1953).

Dialyzable Fraction

Intravenous injection of the dialyzable fraction obtained from the rumen ingesta of sick sheep into a dog caused a rapid drop in blood pressure which soon returned to normal. Repeated injections caused a similar response and did not result in the animal becoming refractive. A previous injection of pyribenzamine prevented the drop in blood pressure. For example, 0.5 ml. of a solution of the dialyzable fraction resulted in a lowering of blood pressure equivalent to that obtained with 30 mcg. of histamine. If, however, 7.5 ml. of a 2 percent solution of pyribenzamine had been previously administered, there was no noticeable affect after injecting 10 ml. of the above dialyzable fraction. Injections of the dialyzable fraction obtained from the ingesta of normal sheep caused no depression of blood pressure.

Identification of Histamine and Tyramine

Histamine and tyramine were identified by paper chromatographic techniques. Upon spraying the chromatograms with diazotized sulfanilic acid and sodium carbonate, red and orange spots appeared. R_f values for these spots using five different solvents are compared with the R_f values of histamine and tyramine in table 1. The R_f values of the red and orange spots correspond to that obtained for histamine and tyramine respectively. The addition of histamine and tyramine to the solution

[2] The PVP was furnished through the courtesy of General Aniline and Film Corporation.

produced no new spots either after one-way development in each of the solvents shown in table 1 or after two-way development using propanol-ammonia and butanol-acetic acid. Segments of the paper chromatograms

TABLE 2. HISTAMINE CONCENTRATION IN RUMEN INGESTA OF OVER-FED SHEEP

Time after over-feeding hours	Sheep number	Histamine in rumen ingesta mcg./ml.	pH of rumen ingesta
Experiment 1			
	1	0	6.6
0	2	0	6.5
	1	0	5.4
8.5	2	0	5.0
	1	1.5	4.5
19	2	0.5	4.4
	1	0	4.5
23.5	2	2.0	4.1
	1	2.0	4.5
27	2	4.0	4.4
	1	>20.0	4.1
60	2	1.0	6.9
Experiment 2			
	3	0	6.5
0	4	0	6.5
	3	0	6.5
1.5	4	0	6.5
	3	0	5.5
18	4	3	5.3
	3	4	4.5
25	4	>20	4.5
Experiment 3			
	5	0	6.5
0	6	0	6.5
	5	3	5.8
18	6	3	4.8
	5	>70[a]	4.2
42	6	>20	5.1
Experiment 4			
36	7	>70[a]	4.2

[a] Sheep died before sample was taken.

corresponding to the R_f value for histamine, were eluted with water and the eluate tested for its effect upon the blood pressure of a dog. A decided drop in blood pressure resulted which could be counteracted by a previous injection of pyribenzamine.

The concentration of histamine in rumen ingesta was determined by using the CAS method directly on the liquid portion of the ingesta. The color intensity of the chromatogrammed spots was compared visually with standards which were prepared by adding varying levels of histamine to histamine-free rumen ingesta and carrying out the separation procedure. The levels of histamine used were in 1 mcg. increments from 1 to 10 mcg. The quantity of histamine found in rumen ingesta of over-fed sheep is given in table 2. In the cases reported, the animals were obviously sick but not critically ill at histamine levels of about 5 mcg. per ml. of rumen ingesta. The sheep whose ingesta contained 20 mcg. of histamine per ml. were acutely ill but recovered. In the cases where the histamine level reached the high values of greater than 70 mcg. per ml. of ingesta, the animals had died. There was, in every case, a direct correlation between the level of histamine in the ingesta and the well-being of the sheep.

In addition to following the occurrence of histamine, the pH of the rumen ingesta was also determined. There was a direct correlation between pH of the rumen, the histamine level of the ingesta and the well-being of the animal. Table 2 indicates that histamine formation became apparent as a value of pH 5 was approached. As the pH continued to decrease, histamine levels increased. The animals became acutely ill when the ingesta had a pH of 4.5 or lower under which conditions histamine levels were high. A correlation between illness of sheep and pH of their rumen ingesta has been reported by Hungate *et al.* (1952) and Scarisbrick (1954). They observed no illness at pH 5 or greater; reduced rumen motility at pH 4.5–5.0; and, very weak to cessation of rumen motility at pH 4.0–4.5.

It was observed by the use of a cinefluoroscope that intravenous injections of histamine into a sheep completely stopped rumen motility and the ability of the animal to eructate but apparently did not interfere with the ability of the animal to swallow.

Summary

1. Histamine and tyramine have been identified as toxic constituents in the rumen ingesta of experimentally over-fed sheep. Histamine levels of greater than 70 mcg. per ml. of ingesta have been obtained.

2. The illness of the sheep was found to be directly correlated with the level of histamine in the ingesta.

3. As the acidity of the ingesta became lower than about pH 5, histamine formation increased. Below pH 4.5, the levels of histamine reached

values greater than 70 mcg. per ml. of rumen ingesta and the animals became fatally ill.

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EFFECT OF STILBESTROL, PROGESTERONE-ESTRADIOL IMPLANTS AND ORAL ADMINISTRATION OF STILBESTROL ON FATTENING LAMBS [1]

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THE large increase in growth rate of lambs and cattle, which is sometimes accompanied by adverse side effects following the administration of stilbestrol implants has stimulated research work with various combinations and levels of hormones and different methods of administering the hormone.

Galloway *et al.* (1952) reported that a combination of 25 mg. diethylstilbestrol and 250 mg. progesterone per lamb implanted subcutaneously in the neck resulted in more rapid gain, higher dressing percentage and higher carcass grade than similar untreated lambs. Jordan (1953) obtained a significant increase in growth rate and feed efficiency when lambs were implanted with 6 mg. of stilbestrol and 50 mg. of progesterone. However, carcass grade and yield were lower in the treated lambs than in the control lambs. Henneman *et al.* (1953) treated feeder lambs with an implant containing 250 mg. of progesterone and 10 mg. of estradiol. These workers reported a 27 percent higher rate of gain on 15 percent less feed per pound of gain with no significant difference in carcass grade, dressing percentage, percent of moisture, or other factors studied. In two separate trials Jordan (1954) implanted fattening lambs with 10 mg. of estradiol and 250 mg. of progesterone. In both trials increased growth rate and feed efficiency occurred. However, carcass grade and yield were lower in the treated lambs. Three lambs out of 24 treated, failed to show break joints and were graded as yearlings. These lambs were marketed in the early part of May. Hale *et al.* (1954) added stilbestrol to lamb fattening rations at two levels, 1.8 mg. and 3.6 mg. per lamb daily. At the lower level daily rate of gain was increased from 14 to 30 percent with a corresponding reduction of 14 to 20 percent in feed costs of the gains. No undesirable effect upon carcass, dressing percentage, or grade was noted. The higher level, 3.6 mg. per lamb daily,

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[2] Stilbestrol feed supplement was donated by Eli Lilly and Company through the courtesy of Dr. J. F. Downing and the hormone implants were donated by Syntex Animal Products through the courtesy of Dr. J. O. Reed.

appeared to be too high for maximum gain, carcass quality and general health of the animal.

The objectives of the trial reported herein were as follows: 1. To determine the relative effect of oral administration of stilbestrol on fattening lambs when fed at three levels. 2. To determine the relative effectiveness of subcutaneous implants of either 12 mg. of stilbestrol or 250 mg. of progesterone and 10 mg. of estradiol. 3. To compare implants with oral administration of stilbestrol.

Material and Methods

High quality Western feeder lambs averaging approximately 70 lb. in weight, were vaccinated for over-eating disease and sheared before being randomly allotted to the various experimental lots. The treatments imposed upon the lambs were as follows: Lot 1 consisted of 30 lambs which were fed in one group. However, three treatments were imposed on this group. Ten lambs served as a control; ten lambs received a hormone implant consisting of a combination of 10 mg. estradiol and 250 mg. progesterone, hereafter to be referred to as Synovex: ten lambs received an implant of 12 mg. of stilbestrol. The remaining treatments were replicated and 10 lambs per lot were fed as follows: Lots 2 and 3—control; Lots 4 and 5 were fed .1 mg. of stilbestrol per lamb daily; Lots 6 and 7, .5 mg. of stilbestrol per lamb daily; Lots 8 and 9, 1.5 mg. of stilbestrol per lamb daily. In lots 4 through 9 the various levels of stilbestrol were mixed with .1 lb. of soybean oil meal. The lambs in all lots received a standard ration consisting of approximately equal parts of shelled corn and alfalfa hay and .1 lb. of soybean oil meal. They were full-fed and no attempt was made to limit the amount of grain or hay in any of the lots. Fresh water, salt, and a trace mineral salt-bone meal mixture were available to the lambs at all times. The lambs were individually weighed at the beginning and at the end of the experiment and group weighed at 14-day intervals during the experiment. Individual carcass grade and average carcass yield for the various lots were obtained at the time of slaughter.

Results and Discussion

The results of the trial are shown in table 1. Lot 1 which consists of 30 lambs is divided into three sub-lots of 10 lambs each as follows: Control, Lot 1-A; Synovex implant, Lot 1-B; and stilbestrol implant, Lot 1-C. There was good agreement between the replication for those lots that received stilbestrol orally and the replications are averaged and presented in the table as one lot and will be discussed in that manner.

Growth Rate and Feed Consumption

A comparison of lots 1-A, 1-B and 1-C shows that the lambs which received Synovex, (lot 1-B) gained .09 lb. more per lamb daily, and those receiving the stilbestrol implant gained .13 lb. more per lamb daily than the controls. These differences are highly significant. However, the difference in rate of gain between the Synovx implant and the stilbestrol implant was not significant. The average daily rate of gain of the orally-fed stilbestrol lambs, 2–9, are quite similar. The average daily rate of gain of the two control lots (2 and 3) is .36 as compared to .37, .39 and .38 for the lambs which received .1 mg., .5 mg. and 1.5 mg. of

TABLE 1. EFFECT OF SYNOVEX, STILBESTROL IMPLANTS AND STILBESTROL FEEDING ON FATTENING LAMBS

(November 3, 1954 to January 12, 1955—70 Days)

Item	1-A Control	1-B [a]	1-C [b]	2 & 3 Control	4 & 5 .1 mg. stil.	6 & 7 .5 mg. stil.	8 & 9 1.5 mg. stil.
Number lambs per lot	10	10	10	20	20	20	20
Initial weight, lb.	69.4	66.8	66.1	71.3	71.4	71.0	70.9
Final wt. of lamb, lb.	97.4	101.1	103.4	96.6	96.9	98.5	97.7
Av. gain per lamb, lb.	28.0	34.3	37.3	25.3	25.5	27.5	26.8
Av. daily gain, lb.	.400	.490	.533	.361	.365	.393	.384
Av. daily ration, lb.							
Shelled corn	1.48	1.48	1.48	1.45	1.46	1.46	1.46
Alfalfa hay	1.55	1.55	1.55	1.57	1.57	1.57	1.56
Soybean oil meal	.10	.10	.10	.10	.10	.10	.10
Feed per 100 lb. gain, lb.							
Shelled corn	371	303	279	403	399	373	380
Alfalfa hay	388	317	291	433	429	400	407
Soybean oil meal	25	20	19	28	27	26	26

[a] Synovex implant contained 250 mg. of progesterone and 10 mg. of estradiol.
[b] Twelve mg. of stilbestrol implants.

stilbestrol per lamb daily, respectively. When compared with the control lambs none of the differences proved to be statistically significant. A direct comparison between the lambs that received implants of either Synovex or stilbestrol and the lambs fed the three levels of stilbestrol cannot be made since only 10 lambs were fed stilbestrol per lot in contrast to lot 1 which contained 30 lambs. However, the difference in response to the implants as compared to oral feeding of stilbestrol is sufficient to suggest that a greater growth response resulted from the implant of either Synovex or stilbestrol than when the stilbestrol was fed orally.

Since the lambs in lot 1-A, 1-B and 1-C were fed as one group the feed consumption as shown in table 1 does not reflect differences that might have existed due to treatment. The lambs in lots 2 and 9 were offered

as much grain and hay as they would consume. However, the average daily feed consumption as shown indicates that the oral administration of stilbestrol did not increase feed consumption nor did the amount of stilbestrol fed per lamb daily have an effect on the amount of feed consumed. Since rate of gain and feed consumption were approximately equal in lots 2 and 9, there is little difference in feed efficiency between the various lots.

TABLE 2. EFFECT OF HORMONE IMPLANTS AND FEEDING ON CARCASS GRADE AND YIELD

Lot No.	Treatment [a]	High choice	Med. choice	Low choice	Good	Carcass yield
		First slaughter				%
1-A	Control	4	4	2		52.5
1-B [b]	Implant	5	3	2		52.4
1-C [c]	Implant	2	7		1	51.6
2	Control	3	2	5		54.3
4	.1 mg. stil.	3	6	1		52.6
6	.5 mg. stil.	6	4			52.8
8	1.5 mg. stil.	5	4		1	53.5
		Second slaughter				
3	Control	5	3	1	1	55.5
5	.1 mg. stil.	5	4	1		53.8
7	.5 mg. stil.	6	4			53.4
9	1.5 mg. stil.	5	3	1	1	53.7

[a] Lambs were fed stilbestrol in lots 4–9.
[b] Synovex implant contains 250 mg. of progesterone and 10 mg. of estradiol.
[c] Implant contains 12 mg. of stilbestrol.

Carcass Data

The effect of Synovex or stilbestrol implants and feeding of stilbestrol at three levels on carcass grade and yield is shown in table 2. The lambs were slaughtered on two different dates. On the first date all the lambs in lots 1-A, 1-B, 1-C and all the lambs in lots 2, 4, 6, and 8 were slaughtered. Two weeks later all the lambs in lots 3, 5, 7, and 9 were slaughtered. The carcass data pertaining to the lambs in lots 1-A, 1-B and 1-C show that there was very little difference in the carcass grade of the controls and the lambs that received Synovex implants. However, the lambs that were implanted with 12 mg. of stilbestrol had fewer lambs that graded high choice and one lamb that graded good. This particular lamb showed a prolapse of the rectum. As a group, the lambs treated with stilbestrol implants were softer in the flank and were not as firm as the lambs in either lots 1-A or 1-B. They lacked the covering over the leg and on the inside of the rib. The carcass yield of the lambs

in lots 1-A and 1-B were similar. However, the lambs implanted with stilbestrol yielded about 1 percent less.

The lambs that were fed various level of stilbestrol produced carcasses that graded as high or higher than the controls at both slaughterings. The lambs that received .1 mg. and .5 mg. of stilbestrol had a higher number of lambs that graded high choice and medium choice than was true of the control lambs. These lambs were very firm and well covered and showed no indication of prominent hips, long, flat legs or high moisture in the carcass. The lambs receiving 1.5 mg. of stilbestrol were not as well covered as the lambs fed the two lower levels of stilbestrol. In spite of the fact that the lambs graded as high or higher than the controls at both slaughtering times their carcasses yielded less than the control lambs. This carcass yield is based on sale weight immediately prior to slaughter and warm carcass weights.

Summary

Fattening lambs treated with implants of either a mixture of progesterone and estradiol, "Synovex," or stilbestrol gained significantly faster than the control lambs (.09 and .13 lb. per lamb daily, respectively). Feeding stilbestrol at either .1 mg., .5 mg. or 1.5 mg. per lamb daily did not significantly increase rate of gain. Carcass grade and yield of lambs implanted with Synovex were equal to the control lambs. However, the stilbestrol implant lowered both carcass grade and yield. The lambs that were fed .1 mg. and .5 mg. of stilbestrol produced higher grading carcasses than the controls. Lambs fed 1.5 mg. of stilbestrol produced carcasses of comparable quality to the controls. The carcass yield based on selling weight of the live lamb and warm carcass weights was lower in all lots fed stilbestrol.

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THE UTILIZATION OF UREA AND BIURET AS SOURCES OF NITROGEN FOR GROWING-FATTENING LAMBS [1]

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UREA can be utilized as a nitrogen source for ruminants; however, the amount of urea used in rations has to be restricted because of possible toxic effects. Biuret, a urea condensation product, has been found by Repp *et al.* (1955) to be less toxic than urea. They found that the feeding of biuret in large amounts produced very little change in blood urea or ammonia indicating that ammonia was released very slowly, if at all, during digestion. They further indicated that the absence of biuret toxicity may be due to a lack of amidase activity in the rumen. Urea toxicity has been explained on the basis of high urease activity of the rumen contents (Dinning *et al.* 1948; Repp *et al.*, 1955). Recently it has been shown by Hale and King (1955) that acute urea toxicity may not be due to ammonia but rather to ammonium carbamate. Biuret, however, is not attacked by urease. By using cellulolytic activity of micro-organisms *in vitro* as an index of nitrogen utilization, Belasco (1954) found that when biuret was added as a nitrogen source, cellulose digestion was only 7 percent of that occurring when urea was added as the nitrogen source. Salsbury (1955), using cellulose digestion as a criterion, has had similar results at this station. it was thought, however, that biuret offered promise as a nitrogen source in ruminant rations since it was non-toxic at high levels of intake and could therefore possibly be used to mix with urea to produce a less toxic nitrogen source.

The purpose of this study was to determine whether biuret could be utilized for growth and fattening of lambs. Crude biuret was also tested. This product is made by the application of heat to urea under suitable conditions resulting in a crude material containing 41 percent biuret, 46 percent urea, 6.5 percent triuret and 6.5 percent cyanuric acid.

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Experimental

Fifty western lambs were drenched with phenothiazine, vaccinated for enterotoxemia, and allotted on the basis of weight and sex into five equal lots. Each lot was divided into two groups of five lambs each. The lambs averaged 75 lb. in weight and were fed 73 days. Wheat straw was used as the roughage in this trial so that the basal mixture would not supply enough protein to give optimum gains unless a nitrogen source was added. Two preliminary trials indicated that a basal ration consisting of corn silage, corn and minerals was not low enough in crude protein to serve as a negative control. The addition of either a non-protein nitrogen source or a preformed protein to this basal ration did not consistently increase the rate of gain.

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

Lot	1	2	3	4	5
Ingredients	Percent of mixture				
Wheat straw (ground)	31.67	31.67	31.67	31.67	31.67
Molasses	6.67	6.67	6.67	6.67	6.67
Corn	51.33	51.33	51.33	51.33	45.53
Alfalfa meal (dehydrated)	8.33	8.33	8.33	8.33	8.33
Dicalcium phosphate	1.30	1.30	1.30	1.30	1.30
T. M. salt	0.70	0.70	0.70	0.70	0.70
Soybean oil meal	...	...	...	...	5.90
Urea	...	0.85	...	...	...
Biuret	...	...	0.85	...	...
Crude biuret [a]	...	...	...	0.85	...

[a] Crude biuret analysis: 41 percent biuret, 46 percent urea, 6.5 percent triuret, and 6.5 percent cyanuric acid.

The basal ration used in the present trial consisted of ground wheat straw, ground corn, molasses, dehydrated alfalfa meal, trace mineralized salt and dicalcium phosphate (table 1). It had an average crude protein content of 7.13 percent. Blackstrap molasses and dehydrated alfalfa meal were incorporated into the ration as it has been shown that both stimulate gains when a poor quality roughage is fed (Bentley *et al.*, 1952). It was thought that the molasses would also improve the palatability of the ration. Urea, biuret and crude biuret were added to the basal to complete the mixture for lots 2, 3 and 4, respectively. The crude protein of the ration of these lots ranged between 9.08 and 9.11 percent. Soybean oil meal replaced part of the corn in the ration of lot 5, bringing the crude protein level up to about 9.7 percent. All rations were approximately equal in energy content. The proximate analyses of the five rations used is shown in table 2. Each lot was started on low

quality hay which was gradually decreased and the experimental rations were gradually increased until at the end of two weeks all lambs were receiving experimental rations. The lambs were fed twice daily an amount they would consume in approximately one hour. They had free access to water and a 1:1 mineral mixture of dicalcium phosphate and trace mineralized salt.

Results and Discussion

Toxicity Studies

Two lambs were drenched with a solution of urea and two with a solution of biuret. Initially, the lambs weighed approximately 65 lb.

TABLE 2. PROXIMATE ANALYSES OF LAMB RATIONS

Lot	1	2	3	4	5
Ration	Basal	Basal + Urea	Basal + Biuret	Basal + Cr. Biuret	Basal + SBOM
			Percent		
Moisture	12.31	13.31	13.55	11.99	11.71
Ash	4.58	4.50	4.75	4.30	4.60
Crude fiber	16.78	16.80	16.28	16.96	16.83
Ether extract	2.62	2.50	3.18	2.67	2.40
Crude protein	7.13	9.11	9.08	9.10	9.69
N-free extract	56.58	53.70	52.74	54.89	54.83

each. The drenches were administered at weekly intervals just before the morning feed. The feed was one pound of grain per lamb and alfalfa hay and trace mineral salt free-choice. No toxicity symptoms were noted until the urea levels reached 25 gm. per 100 lb. of body weight. At this dosage both lambs appeared slow to eat. The following week one of the urea lambs received the same dosage and developed labored breathing, but recovered after 70 minutes. The other lamb was given urea at the rate of 28.5 gm. per 100 lb. of body weight. This lamb developed labored breathing in 15 minutes, was down in 30 minutes, had tetanic convulsions in 50 minutes, and developed bloating. Finally, death occurred two hours after the urea administration. Dinning *et al.* (1948) found that a 500 lb. steer developed toxicity symptoms and death when given a solution containing 23 gm. of urea per 100 lb. of body weight.

Two lambs given biuret drenches showed no toxicity symptoms at a level of 31 gm. per 100 lb. of body weight.

TABLE 3. RESULTS OF 73-DAY LAMB TRIAL
(Two Replicates, 5 Lambs Each, per Treatment)

Lot	1	2	3	4	5
Ration	Basal	Basal + Urea	Basal + Biuret	Basal + Cr. Biuret	Basal + SBOM
Av. initial wt., lb.	75.3 ± 2.4 [a]	75.2 ± 2.5	75.7 ± 2.5	75.1 ± 2.1	75.1 ± 2.5
Av. final wt., lb.	88.8 ± 3.3	96.7 ± 2.7	96.9 ± 4.4	94.9 ± 2.9	97.0 ± 3.2
Av. daily gain, lb.	0.18 ± .02	0.30 ± .03** [b]	0.29 ± .03**	0.27 ± .02*	0.30 ± .03**
Av. daily feed comsumption, lb.	2.73 ± .08	2.78 ± .00	2.88 ± .00	2.84 ± .02	2.85 ± .02
Av. feed/lb. gain, lb.	14.95 ± .20	9.76 ± .41** [c]	9.86 ± .49**	10.52 ± .21**	9.53 ± .47**
Appraised value/cwt., dollars	14.50	15.00	15.00	15.00	16.00
Dressing per cent [d]	46.3	48.5	48.1	49.5	48.9
Carcass grades: [e]					
No. choice	4	6	4	7	5
No. good	3	2	5	2	4
No. utility	3	2	..	1	1

* Significant at the 5 percent level.
** Significant at the 1 percent level.
[a] Standard error of the mean is given with each average.
[b] Least significant difference at 1 percent level is 0.0915 lb./day. Difference between lot 4 and lot 1 is 0.09.
[c] Least significant difference at 1 percent level is 3.00 lb. feed per pound of gain.
[d] Shrink was calculated to be 2½ percent of hot carcass weight.
[e] One sheep was withdrawn from lot 3 prior to selling and carcass results do not include data from this animal.

Feeding Trial

The results presented in table 3 indicate that the addition of the non-protein nitrogen sources or soybean oil meal significantly increased the average daily gains (P less than 0.01 in lots 2, 3 and 5, P less than 0.05 in lot 4). The average daily gain of lot 4 very closely approached the highly significant figure. The average daily gain of lots 2, 3 or 4 was not significantly different from the average daily gain of the sheep in lot 5 fed soybean oil meal.

When either urea, biuret, crude biuret or soybean oil meal was added to the basal ration, an increase of about 0.10 lb. in the average daily gain resulted.

Feed efficiency was significantly higher in lots 2, 3, 4 and 5 (P less than 0.01). The basal group (lot 1) consumed an average of 14.95 lb. of feed per pound of gain. Lots 2, 3, 4 and 5 consumed an average of 9.76, 9.86, 10.52 and 9.53 lb. of feed per pound of gain, respectively.

There appeared to be little difference in dressing percentage and carcass grade among lots, but the results all favored the lots fed the higher protein rations (table 3).

The mechanism by which the nitrogen is liberated from the biuret molecule is, as yet, unknown. However, it is interesting that the *in vitro* tests with biuret indicated that this compound was not utilized as a source of nitrogen. This would indicate that results obtained with *in vitro* studies should always be confirmed by animal experimentation.

Summary

In a feeding trial involving fifty 75-lb. lambs, a 7.13 percent crude protein basal ration was fed. Adding either urea, biuret or crude biuret, or replacing part of the corn with soybean oil meal, significantly increased the average daily gain and feed efficiency of the lambs. No significant differences were noted among the lots fed the various supplemental nitrogen sources.

It is concluded that, under the conditions of this experiment, urea, biuret and crude biuret are satisfactory sources of supplemental nitrogen for growing-fattening lambs. In addition, biuret appears to be less toxic than urea when fed in large amounts.

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EFFECT OF GRINDING AND PELLETING UPON DIGESTIBILITY OF A RATION BY LAMBS

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CONSIDERABLE interest in self-feeding pelleted fattening rations to cattle and sheep has developed among stockmen. Usually the feeds in such rations are ground sufficiently fine to permit satisfactory pelleting. Studies by Heller *et al.* (1941) indicate that extremely fine grinding impairs palatability and reduces the digestibility of rations for sheep. The effects of pelleting on the nutritive value of a feed are not fully known.

Murdock and Miller (1951) working with lambs reported that pelleting a finely ground ration increased the digestibility of crude fiber. Various workers (Bell *et al.*, 1954; Noble *et al.*, 1953, 1954) have reported that pelleting a ground mixed ration increases the efficiency by which it is utilized by fattening lambs.

This experiment was designed to study the relative digestibilities of three rations composed of the same ingredients. In one ration (natural) the feeds were fed without grinding; in another, the same feeds were ground; and in another, they were ground and pelleted.

Experimental

Twelve western wether lambs were used in the experiment which consisted of three separate digestion trials. In the first trial the lambs were randomly allotted to three groups of four lambs each and each group fed a different ration with respect to physical state. In the second trial they were randomly allotted with the restriction that no lamb be fed the same ration as in the preceding trial. In the third trial they were allotted to the rations which they had not been fed in the first and second trials. The daily ration was two pounds of a mixture composed as follows: prairie hay, 30 percent; alfalfa hay, 20; yellow corn, 34; cottonseed meal, 8; and cane molasses, 8.

Salt was fed, in addition, at the rate of 9 gm. per lamb per day. The hay in the natural ration was fed as long hay. The corn was fed as whole shelled corn. The hay in the fine ground and pelleted rations

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was ground through a one half inch screen in a hammer mill and the corn was ground through a 1/16-inch screen. The cottonseed meal in all rations was fed as purchased.

The lambs were individually fed in stanchions twice daily and when not eating were allowed freedom of a small pen with access to water. Each trial consisted of a 10-day preliminary period followed by a 10-day collection period during which feces were collected by means of a light harness and canvas bag. Techniques were essentially as described by Tillman *et al.* (1954). Analyses of feed and feces were made according to accepted methods (A.O.A.C., 1950). The data were treated statistically by analysis of variance as described by Snedecor (1946).

Results and Discussion

At the low level of feed intake in these trials there were no feed refusals. No difficulty was encountered in getting the lambs on feed and no digestive disturbances were observed. The allotments of the natural

TABLE 1. AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY FOR A RATION FED IN THREE PHYSICAL STATES [a]

Ration	Coefficients of digestibility [b]					
	Dry matter	Organic matter	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
Natural	71.2(1.1)**	72.4(1.5)**	66.1(1.3)	63.1(4.7)*	52.7(2.6)**	80.0(1.0)**
Ground	68.5(0.9)**	69.1(1.2)**	62.8(1.1)**	63.2(4.3)	46.5(1.4)**	77.8(0.2)*
Pelleted	70.2(1.8)	72.7(1.9)	67.9(2.1)	69.6(4.8)	49.7(4.2)	79.0(1.9)

[a] The figure in parenthesis is the standard error of the mean. Comparisons made in analysis of variance were natural ration versus a combination of the other two, and ground versus pelleted.
[b] For 80-lb. lambs.
* P = less than .05.
** P = less than .01.

and ground rations were consumed by approximately 45 minutes after feeding; however, the pelleted feed was consumed in approximately 25 minutes.

A summary of the coefficients of apparent digestibility is presented in table 1.

The average coefficients of apparent digestibility for organic matter in the natural, ground, and pelleted rations were 72.4, 69.1, and 72.7 percent, respectively. The value for organic matter digestibility of the natural ration was compared with the combined values of the ground and pelleted rations; the difference was highly significant (P less than .01). Also, the digestibility of organic matter of the pelleted

ration was significantly higher (P less than .01) than that of the ground ration.

The average coefficients of apparent digestibility for crude fiber in the natural, ground, and pelleted rations were 52.7, 46.5, and 49.7 percent, respectively. The difference in fiber digestibility between the natural ration and the combined values of the ground and pelleted ration was highly significant (P less than .01). Much of this difference was due to the low value obtained with the ground ration. The digestibility of the crude fiber of the pelleted ration was significantly higher (P less than .01) than that of the ground ration.

The average apparent digestion coefficients for crude protein in the natural, ground, and pelleted rations were 66.1, 62.8, and 67.9 percent, respectively. The value for the pelleted ration was significantly higher (P less than .01) than that for the ground ration.

Nitrogen-free extract digestibility was highest in the natural ration. The digestibility of the nitrogen-free extract of the pelleted ration was significantly higher (P less than .05) than that of the ground ration.

In this experiment grinding of the ration tended to lower the apparent coefficients of digestibility of organic matter, crude fiber, crude protein, and nitrogen-free extract, and pelleting of the ground ration tended to raise these coefficients to the level of the natural ration.

A significant (P less than .01) interaction between trial and treatment was due to the higher digestibility of the natural ration compared to the pelleted ration in the first and third trials, but a higher digestibility for the pelleted ration in the second trial.

Summary

In a digestibility experiment consisting of three trials, 12 wether lambs were individually fed the same ration in three different physical states: (1) natural (long hay, whole grain), (2) ground, and (3) ground and pelleted. The ration was composed of prairie hay, alfalfa hay, corn, cottonseed meal, and molasses. Grinding the whole ration lowered its digestibility. Pelleting the ground ration restored its digestibility to approximately the same level as observed with the ration in the natural state. The average apparent digestion coefficients for organic matter, crude protein, and crude fiber were significantly higher (P less than .01) for the pelleted ration than for the ground ration. Values for the apparent digestibility of organic matter, crude fiber, and nitrogen-free extract were significantly higher (P less than .01) than the combined values obtained with the ground and pelleted rations.

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STUDIES ON A CATTLE DISEASE OF UNKNOWN ORIGIN IN SOUTHEASTERN UTAH

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THE cattle of southeastern Utah have been plagued for many years by a malady locally known as "Brisket Disease." The seriousness of the disease is indicated by a morbidity rate varying from one to five percent of all the cattle grazing these areas and almost a one hundred percent mortality rate among affected animals if left on the range untreated. The disease usually runs a course of a few to many weeks.

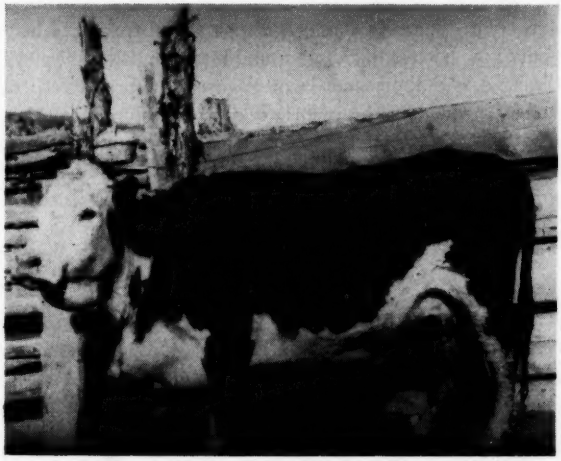

Figure 1. Animal showing Brisket Disease symptoms. Note edema of throat and brisket and dull hair coat with dry ends.

The Disease

Clinical Description

The disease gets its name from the swollen brisket, a major symptom in the latter stages of the disease (figure 1). The earliest symptoms

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are a dejected attitude, closely followed by a rough, lusterless hair coat, a dark profuse diarrhea, rapid loss of condition, ascites, and finally an edematous condition starting in the throat and extending down to the brisket and body underline; and, in extreme cases to all lower extremities of the animal. Respiration is labored, pulse weak, the jugular vein is frequently distended and shows pulsation, and in many cases the temperature is above normal. Mucous membranes are pale and there are generally nasal and occular discharges.

Post-Mortem Findings

Post-mortem examination shows excessive amounts of straw-colored fluid in the abdominal cavity, thoracic cavity, and throughout the body tissues. This varies with the amount of swelling or edema present. In extreme cases 20 gallons or more of fluid have been found in the body cavities. The liver is usually enlarged, has extended fibrosis and is a dark blue color. The gall bladder is usually distended. The heart is greatly enlarged, becoming almost round in shape and flabby.

The lining of the abomasum in most cases is a bright red color with several ulcers present in the pyloric region. Histopathological examination of the liver shows a marked centrilobular congestion and parenchymal necrosis terminating in extensive fibrosis. Usually there is an increased number of leucocytes and iron deposits (hemosiderin) throughout the organ.

Review of Literature

Glover and Newsom (1915, 1917) reported that cattle in Colorado have been affected for a long time by a disease characterized by a swelling of the brisket. They believed these symptoms were brought about by exertion of the heart before acclimatization at high elevations, or in calves, by inherited cardiac weaknesses. Glover and Newsom (1918) have shown that the hearts of cattle raised at high altitudes average 0.879 lb. heavier per 1000 lb. of body weight than the hearts of animals raised at sea level.

A disease called "St. George's Disease" which has been reported in Australia has symptoms similar to Brisket Disease (Maunder, 1947). This disease occurs at low altitudes and the cause is unknown. It is believed that the disease could be caused by a toxic element in the diet or by a dietary deficiency of one or more nutrients. Animals removed from the area generally recover.

Glenn (1953) reported general observations on a malady similar to

Brisket Disease, that has occurred in certain parts of Colorado, Wyoming, and New Mexico for more than 40 years. His observations may be summarized as follows: The condition is not infectious or contagious; cows recover when moved to a new environment, but usually die if put back in the original one. There is a general disturbance in the blood system characterized by more fluid in the heart sac, more fluid in the pleural sac surrounding the lungs, and more fluid in the lungs than is normal. It occurs at low altitudes as well as high, but is more fatal and simpler to diagnose at 9,000 feet and over than at 4,000 feet and below. It occurs only where there is seepage water.

Method of Procedure and Results

Certain symptoms of the disease seemed to indicate that it could be caused by a deficiency of copper and cobalt. Analyses of some of the range plants also indicated that they were low in these elements. A series of experiments, therefore, were conducted to determine if the trace elements or other supplements would prevent or cure the disease. The plan of these experiments was as follows: 1. Supplementary feeding of all animals on 7-mile and U. M. Ranges. 2. Additional feeding of calves on 7-mile Range. 3. Drenching of cattle with trace minerals on a fenced section of pasture on U. M. Range. 4. Treatment of sick cattle on 7-mile and U. M. Ranges.

Supplemental Feeding of All Cattle

Mineral supplements were fed free choice in a one- or two-compartment box as outlined in tables 1 and 2 during the grazing seasons of 1948–53. During the years 1948–52 the U. M. Range cattle served as a control and received only bonemeal and salt in the supplement, while the 7-mile Range cattle received bonemeal, salt, copper, and cobalt and in 1952–3 bonemeal, salt, copper, cobalt and iron as a supplement. In 1953 the cattle on U. M. Range received about one pound of ground alfalfa hay per head per day to determine if the hay would prevent the disease.

The ground alfalfa hay was fed in troughs and crushed salt was used to regulate the consumption to about one pound of hay per day. Through trial and error it was found that three parts hay and one part salt by weight was the proper ratio to obtain the desired consumption. The animals readily adjusted themselves to this mixture until the grass started to get dry and short in the latter part of September. The distribution after this time was not very satisfactory.

TABLE 1. DESIGN FOR FEEDING MINERAL SUPPLEMENTS TO CATTLE ON 7-MILE AND U. M. RANGES

Year and range	Free choice mineral supplements in boxes	
	Compartment 1	Compartment 2
	Supplement No.	Supplement No.
1948–50		
7-mile Range	1	..
U. M. Range	2	..
1951		
7-mile Range	1	3
U. M. Range	2	..
1952		
7-mile Range	4	5
U. M. Range	2	..
1953		
7-mile Range	4	5
U. M. Range [a]	2	..

[a] Cattle on this range also received a mixture of salt and ground alfalfa hay in such proportions that they ate about one pound of hay per head per day.

During the grazing seasons 1948–52 incidence of the disease and death among animals was in general higher on U. M. Range where the animals received only bonemeal and salt than among the cattle on 7-mile Range that had access to the mineral mixture containing salt, bonemeal, copper and cobalt or salt, bonemeal, copper, cobalt and iron

TABLE 2. INGREDIENTS USED IN SUPPLEMENTS

Ingredients	Number [a]								
	1	2	3	4	5	6	7	8	9
Crushed salt, lb.	100	100	100	100	100	20			
Bonemeal, lb.	100	100		100		20			
Copper sulfate, gm.	227		227	227	227	45	105	36	13
Ferrous sulfate, gm.				227	227			36	13
Cobalt sulfate, gm.	28		28	14	14	6	6		2
Cobalt chloride, gm.								2	
Soybean oil meal, lb.						2000			
Dried distillers solubles, lb.						50			
Water, ml.							3600	3800	3800

[a] Animals on No. 7 were drenched twice each week with 20 ml. of the supplement; those on No. 8 and 9 were drenched twice each week with 55 ml.

TABLE 3. SUMMARY OF DEATHS AND INCIDENCE OF BRISKET DISEASE AMONG MATURE ANIMALS ON 7-MILE AND U. M. RANGES

Range	Number of cattle on range	Incidence		Died	
		number	%	number	%
1948					
7-mile	1100	2	0.2	1	0.1
U. M.	700	10	1.4	7	1.0
1951					
7-mile	1100	3	0.3	1	0.1
U. M.	700	1	0.1	0	0.0
1952					
7-mile	1100	3	0.3	1	0.1
U. M.	700	8	1.1	5	0.7
1953					
7-mile	1100	1	0.1	1 [a]	0.1
U. M.	700	3	0.4	2	0.3
7-mile average	1100	2.25	0.2	1	0.1
U. M. average	700	5.75	0.8	3.75	0.5

[a] This animal was slaughtered and tissue sections made of the affected organs to be used for histopathological study. (No data were available for 1949 and 1950.)

(table 3). There was no apparent difference in the hemoglobin, calcium, phosphorus or copper content of the blood of animals on 7-mile or U. M. Range during 1948–9 (table 4). All values were within the normal

TABLE 4. AVERAGE HEMOGLOBIN, COPPER, PHOSPHORUS, AND CALCIUM VALUES FOR BLOOD OF ANIMALS ON DIFFERENT ENVIRONMENTS IN 1948 AND 1949

Cattle and area	Date	Blood	Plasma		
		Hemoglobin	Copper	Calcium	Phosphorus
		gm./100 ml.	ppm.	mg./100 ml.	mg./100 ml.
College cattle	9/16/49	14.1(36) [a]	.....	.....	.....
U. M. cattle	11/1/49	13.4(38)	0.115(38)	12.2(19)	5.84(19)
7-mile cattle	11/1/49	13.3(31)	0.114(32)	11.8(32)	6.13(32)
7-mile cattle	6/29/49	11.9(27)	.....	.....	.....
7-mile cattle	9/13/49	.....	0.153(20)	11.6(20)	5.64(20)
U. M. cattle	9/14/49	.....	0.132(13)	11.4(13)	5.16(13)
7-mile cattle	10/1/48	.....	.....	14.0(21)	5.48(21)
D. Brian (owner)					
U. M. cattle	10/1/48	.....	.....	13.8(9)	5.46(9)
L. Forsyth (owner)					
U. M. cattle	10/1/48	.....	.....	15.2(16)	4.29(16)
C. Albrecht (owner)					
7-mile cattle	6/29/49	11.9(27)	0.141(27)	12.0(24)	5.99(24)

[a] Number in parenthesis indicates number of samples taken from different individual animals.

range (Long *et al.*, 1952; Matrone *et al.*, 1947; Ferguson *et al.*, 1943; Watkins and Knox, 1948; Rusoff and Piercy, 1946). From general observations of the animals it seemed that animals receiving the salt, bonemeal, and trace minerals appeared more thrifty and their hair coats had more luster than the animals receiving only bonemeal and salt.

During the 1953 grazing season approximately 700 cattle and 350 calves on U. M. Range consumed about 33 tons of alfalfa hay and 15 tons of salt, or approximately 0.8 lb. of hay and 0.4 lb. of salt per head per day. The animals seemed to suffer no ill effects from the excess salt.

Incidence of the disease on U. M. Range was less this season than in 1952. Of the 700 mature animals on the U. M. Range only three animals or about 0.4 percent were affected with Brisket Disease as compared with eight during 1952. How much of this difference can be attributed to year effect and how much to the alfalfa hay cannot be determined, but it would seem to indicate that alfalfa hay was a factor in preventing or controlling the disease.

Supplemental Feeding of Calves

The calves on U. M. Range had access to the same supplements as the older cattle for all six years, 1948–53 (table 1). The calves on 7-mile Range received the same supplement as the older cattle during the seasons 1948–50. During the season of 1951 the calves on 7-mile Range received a protein supplement (table 2, number 6) as well as the same mineral supplement the older animals were given. Creeps were constructed to facilitate feeding of the extra supplements. The mineral supplements were also placed within the creeps so the calves would not have to compete with the older animals. The protein pellet was not satisfactory because during the rainy season it would get wet and form a mash which the calves refused to eat. It was not possible to determine the average consumption of the protein supplement.

Good quality alfalfa hay was used in place of the protein pellet during the 1952–3 grazing seasons. Self-feeder hay mangers were constructed within the creeps and alfalfa hay was fed free choice. The calves received approximately two pounds per head per day.

It was difficult to determine to what extent the calves were utilizing the mineral supplements on the range where they had to compete with the older animals. The calves that used the creeps ate approximately three times more of the mineral mixture containing bonemeal than of the mineral mixture without bonemeal. It seemed that approximately 90 percent of the calves on 7-mile Range used the creeps.

Incidence of the disease and death among calves was considerably higher on U. M. Range where the calves had only bonemeal and salt than on 7-mile Range where the calves had access to alfalfa hay and the salt, bonemeal and trace mineral mixture, except during the year of 1951 (table 5). During the year of 1951 there was a higher percentage of calves affected with Brisket Disease on 7-mile Range than on U. M.

TABLE 5. SUMMARY OF DEATHS AND INCIDENCE OF BRISKET DISEASE AMONG CALVES ON 7-MILE AND U. M. RANGES

Range	Number of calves on range [a]	Incidence		Died	
		number	%	number	%
1948					
7-mile	600	19	3.2	19	3.2
U. M.	350	8	2.2	8	2.2
1951					
7-mile	600	12	2.0	12	2.0
U. M.	350	4	1.1	4	1.1
1952					
7-mile	600	10	1.7	9	1.5
U. M.	350	21	6.0	16	4.6
1953					
7-mile	600	7	1.2	6	1.0
U. M.	350	5	1.4	3	0.9
7-mile average	600	12	2.0	11.5	1.9
U. M. average	350	9.5	2.7	7.75	2.2

[a] Estimated from number of female animals and percentages of calf crop. No data were available for 1949 and 1950.

Range. The above results would seem to indicate that either the alfalfa hay or trace minerals were aiding in the control of the disease among the calves.

There was no way of determining how much of the ground alfalfa hay the calves on U. M. Range consumed during the 1953 grazing season as they had to compete with the larger animals for it.

Drenching Cattle with Trace Minerals in the U. M. Range Section

A fenced section of range land on U. M. Range was used for a controlled experiment during the grazing seasons 1951–3. Each year approximately 100 animals were paired with consideration to age, sex, breed, class, weight, and condition. One member of each pair was

drenched twice each week with mineral solution 7, containing copper and cobalt (table 2) during 1951, and with mineral solution 8, containing copper, cobalt and iron (table 2) during 1952 and 1953. The other member of each pair was a control animal. All animals had free access to the same pasture and mineral mixture 2 containing salt and bonemeal (table 2). The animals were observed twice each week for symptoms of the disease and weighed every two weeks.

There were no significant differences in body weight gains in the treated and control animals for any year or over the period of the three years. There were no cases of Brisket Disease among either the control or treated animals in the 1951 and 1953 grazing seasons. There were three cases of Brisket Disease during the 1952 season, two in the control group and one in the treated. There was no significant difference in the hemoglobin values between the treated and control groups. Thus, with the number of cattle used in this experiment, it was not possible to demonstrate any marked effect of trace minerals in the prevention of the disease. It must, however, be remembered that even on the open range the disease only occurs in one to five percent of the animals.

Treatment of Sick Animals

All animals showing symptoms of Brisket Disease during the 1948–50 seasons were picked up by the Association riders and were trucked to Logan. When the sick animals arrived in Logan they were placed on treatments. Blood analyses were made on these animals and a liver biopsy was performed as soon as possible after they had reached the College. Two of the animals were fed only grass hay and appeared to have recovered, but when placed back on the range the following year they became sick again and were once more brought to the College for treatment. After being fed alfalfa hay and copper sulfate, they again recovered. They have been back on the range for three years and have shown no ill effects. Liver sections taken by biopsy from the affected animals contained large amounts of iron and were low in copper. After the animals had apparently recovered the iron content decreased and the copper content increased. This change accompanied a marked improvement in physical well-being in the animals.

During the grazing seasons 1951–3 permanent personnel were on the project and the sick animals were picked up on the range and brought to the sick pastures on their respective ranges. They were placed on treatments 1 to 9 at random (table 6). In 1951, 16 calves and 4 mature animals were placed on treatments 1, 2, 3, and 4. All of the calves died

and one of the mature animals died. Two of the animals that recovered and the one that died were on treatment 3 (alfalfa hay, copper sulfate and cobalt sulfate) and the other animal that recovered was on treatment 4 (grass hay, copper sulfate and cobalt sulfate).

During the grazing season of 1952 there were 31 calves and 11 mature animals on both ranges that were affected with Brisket Disease and were placed on treatments 1, 5, 6 and 7 at random. Of the 31 calves, 25 died and 6 recovered. All 6 of the calves that recovered were on treatment 5 (alfalfa hay). Of the 11 mature animals affected, 6 died

TABLE 6. RESPONSE OF ANIMALS TO VARIOUS DIETARY TREATMENTS

Treatment No.[a]	Mature animals		Calves		Total
	Died	Recovered	Died	Recovered	
1	2	..	10	..	12
2	..	..	14	..	14
3	1	2	..	..	3
4	..	1	..	..	1
5	1	5	4	6	16
6	2	..	12	..	14
7	2	1[b]	3	..	6
8	1	..	2	..	3
9	1	..	2	..	3
Total	10	9	47	6	72

[a] (1) Control, pasture free choice and limited salt consumption; (2) Pasture free choice and 20 ml. of supplement 7 (table 2) twice each week, and limited salt consumption; (3) Cache Valley alfalfa hay free choice and 20 ml. of supplement 7 twice each week and limited salt consumption; (4) Wayne County grass hay free choice and 20 ml. of supplement 7 twice each week, and limited salt consumption; (5) Sevier County alfalfa hay free choice and limited salt consumption; (6) Pasture free choice. 55 ml. of supplement 8 (table 2) twice each week, and limited salt consumption; (7) Pasture free choice, 100 gm. of trace mineral mixture daily, and limited salt consumption; (8) Pasture free choice, 20 lb. of cottonseed meal daily, and limited salt consumption; (9) Pasture free choice, 100 gm. of alfalfa ash daily, and limited salt consumption.

[b] This animal was on treatment 9 for about three weeks and was then fed alfalfa hay; it made a complete recovery.

and 5 recovered. All 5 of the animals that recovered had been receiving treatment 5 (alfalfa hay).

There were 12 calves and 4 mature animals to place on treatments during 1953. Six of the calves were taken to Logan and fed alfalfa hay and of the other six two each were placed on treatments 4, 8 and 9. Of the 6 calves brought to Logan 3 recovered and 3 died. These six were not included in the table of dietary treatments (table 6). The 6 calves placed on the three treatments on the range died. The 4 mature animals were placed one each on each of treatments 1, 7, 8 and 9. The

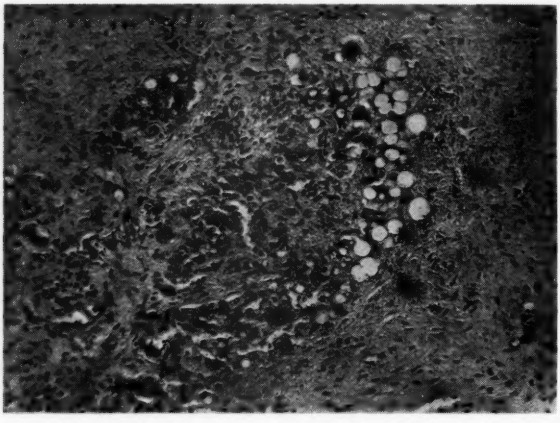

Figure 2. Microphotograph of liver from animal with Brisket Disease.

animals on treatments 1, 8 and 9 died and the animal on treatment 7 had to be taken to Logan because the winter had set in on the range. There was no way to feed this animal except to give it alfalfa hay. It made a complete recovery by February 5, 1954.

Apparently the main difficulty with calves was in getting them to rustle forage and even when alfalfa hay was given the calves refused to eat it in sufficient amounts to meet their requirements. After a couple of days of illness the calves nursed little and in about a week, usually, stopped nursing entirely.

Much of the same trouble was encountered with mature animals as with the calves in that they foraged little. The animals on the trace minerals did appear to make sporadic improvement but eventually succumbed to the disease while the control animals that received pasture only, steadily became worse and finally died. The animals that died while being fed alfalfa hay were usually in advanced stages of the disease and would not eat the hay.

Histological examination of the recovered animals showed that the livers had returned to normal size and color, and the liver cells had become normal (figures 2 and 3). The necrotic areas were replaced with normal liver tissue and the deposits of iron were absorbed. The abomasum lining returned to normal color and the ulcers were healed when the animal had recovered.

Discussion and Suggestions for Control

Brisket Disease has been cured by feeding alfalfa hay to cattle with-

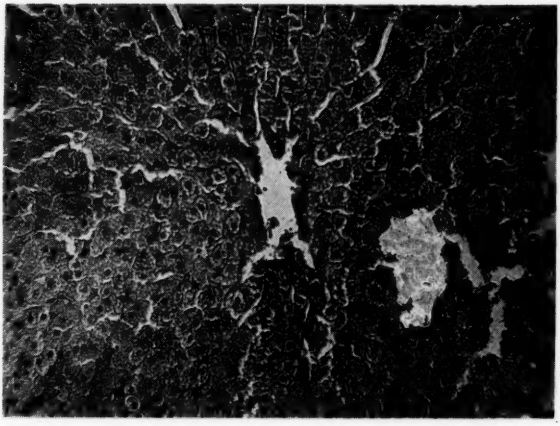

Figure 3. Microphotograph of liver from normal animal.

out moving them off the range. Thus it would seem that the condition is caused by a nutritional deficiency or a toxicity, or a combination of these. Moreover, it does not appear to be caused primarily by altitude as the disease occurs on 7-mile and U. M. Ranges in Sevier County which have elevations of about 9,500 feet, yet apparently does not occur on the Manti Range in Sanpete County which lies north of the above ranges and has an elevation of approximately 10,000 feet. This disease has also been known to occur in cattle that have never been out of the Loa Valley in Wayne County where the elevation is approximately 7,000 feet.

A controlled breeding program may help to control the disease especially among calves. Many of the calves are born in June or July and even later, and it is among these calves that Brisket Disease appears to be the most prevalent. Also these calves are weaned along with the older calves as soon as the cattle come off the range on November first and consequently are small when put out on the range the following year. It is suggested that the cows be bred to calve sometime in March or April. To accomplish this, arrangements should be made to keep the bulls away from the cows except during the breeding season.

The numerous pot holes on these ranges where the cattle have access to seepage water may be a factor in the disease. During the course of this project it has been observed that many of the cattle that come down with Brisket Disease are found in these pot holes or adjacent areas.

Summary

A disease locally called "Brisket Disease" has plagued livestock of southeastern Utah for many years. The disease is characterized by a loss of appetite, edema (swelling) of the brisket and throat region, and a genaral unthrifty condition.

The theory that the disease is caused by altitude does not fit in with the experience of the cattle raisers in Utah.

Experiments were conducted to determine if trace elements or other supplements would prevent or cure the disease. The experiments were divided into four phases: (1) Supplementary feeding of all animals on both ranges, (2) additional feeding of calves on one of the ranges, (3) drenching cattle with trace minerals in a fenced section of range pasture, and (4) treatment of sick animals with various supplements.

Cattle on 7-mile Range received the trace minerals, copper, cobalt and later iron along with salt and bonemeal, while those on U. M. Range received only bonemeal and salt. Incidence of the disease appeared to be less among the cattle receiving the trace minerals.

In 1953 cattle on U. M. Range received a supplement of ground alfalfa hay at the rate of approximately one pound per head per day. Salt was used as regulator. The animals suffered no ill effect from the excess salt and incidence of the disease on this range was less than in any other year.

Calves on 7-mile Range were creep fed a protein pellet one year and alfalfa hay for two years. The value of protein pellets as a preventive measure for Brisket Disease was not satisfactorily determined. There appeared to be less incidence of Brisket Disease among calves that received the alfalfa hay than among those not receiving it.

A controlled experiment drenching animals with copper, cobalt, and iron was conducted for three consecutive years. There were no significant differences in gain of body weight, hemoglobin values, and incidence of the disease.

Animals that became affected with Brisket Disease were placed on various treatments to determine if the disease could be cured at the same elevation as it developed. Of the various treatments used in treating the sick animals only alfalfa hay appeared to bring about a recovery.

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SERUM VALUES IN WHEAT PASTURE POISONING CASES [1]

H. R. CROOKSHANK [2] AND FRANK H. SIMS [3]

IN the winter wheat grazing area and more particularly in the Texas and Oklahoma Panhandles, there develops a condition known locally as wheat pasture poisoning when cattle are allowed to graze on the growing wheat plant. This condition is most pronounced during periods of lush growth with a plentiful moisture supply.

Wheat pasture poisoning symptoms begin with undue excitement, incoordination, and loss of appetite. As the condition progresses, viciousness, staggering, and falling develops. Nervousness becomes more apparent with muscular twitching, particularly of the extremities. The animal has an anxious expression and may grind its teeth and salivate profusely. The third eyelid protrudes or flickers as is seen in tetanus. General tetanic contractions of the muscles follow until the animal nears a state of prostration, however, a sudden noise or merely touching the animal will cause a reflex response. Next to develop are labored breathing and a pounding heart followed by a comatose condition. If left untreated, convulsions with periods of relaxation will be seen which terminate in death. Six to ten hours usually are required from the time the first symptoms develop until the animal passes into the comatose condition. If treatment is not initiated before coma, there is little chance of recovery.

The most commonly used treatment is the intravenous or intraperitoneal injection of a solution of calcium gluconate with or without fortification with glucose, magnesium, or phosphorus. The exact cause or the prevention of wheat pasture poisoning is not known.

Experimental

During the course of investigations on wheat pasture poisoning conducted at PanTech Field Laboratory by the Texas Agricultural Experiment Station, the Texas Technological College, and the Animal and Poultry Husbandry Research Branch, Agricultural Research Service, U. S. Department of Agriculture, from September 1949 through May 1954, serum samples were obtained from 60 untreated cases of wheat

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pasture poisoning which were not complicated by other conditions. Of this number, 43 were seen during the 1953–54 winter wheat grazing season.

All cases were observed in cows two years of age or older, who were pregnant, had a calf at side, or both. The time the cow had the attack varied from the 5th month of pregnancy to 6 or 7 months post-partum. The length of time on wheat varied from 1 week to 6 months. Most cases occurred between 60 and 150 days on winter wheat pasture and in cows having calves under 60 days of age. Supplementing the pasture with sorghum bundles, mineral mixtures, sorghum silage, etc., had no effect in preventing this condition. Many reported cases of wheat pasture poisoning in calves, steers, and dry cows were investigated. However, the only cases we observed occurred under the conditions outlined above. Cases were found in beef, dairy, and crossbred cows.

This paper presents our findings on the composition of the blood sera from wheat pasture poisoning cases and of sera from cows grazing winter wheat pasture and not showing any symptoms of wheat pasture poisoning. The cows from which the values termed normal in this report were obtained were comparable in age, condition, and length of time on wheat to the cows which had attacks of wheat pasture poisoning.

The following determinations were made on the serum: Alkaline phosphatase (Bodansky, 1933), inorganic phosphate (Fiske and Subbarow, 1925), total calcium (Clark and Collip, 1925), diffusible calcium (McLean and Hastings, 1935), magnesium (Denis, 1922), potassium (Mosher *et al.*, 1949), total proteins, albumin, globulin (Weichselbaum, 1946), and the albumin-globulin ratio.

Sera from 60 wheat pasture poisoning cases occurring in the Texas Panhandle were analyzed while the normal values were obtained from 185 samples of serum from Hereford cows grazing winter wheat at PanTech Farms.

As will be seen from table 1, our data indicated significant differences in certain instances and suggestions of possible significance in others in the composition of serum from wheat pasture poisoning cases when compared with the normal levels. A lowered total and diffusible calcium, magnesium, and albumin-globulin ratio were indicated in the affected animals. Total calcium was depressed well below our normal level while the diffusible calcium definitely approached the tetany level (2.5 mg. per 100 ml.). The total serum protein level appeared to be elevated with the increase occurring in the globulin fraction. This resulted in a decreased albumin-globulin ratio. Serum magnesium was

decreased below our normal level. A slight decrease in inorganic phosphate seemed apparent. Because of the extreme variation found in the alkaline phosphatase of the normal cows, it was not possible to make any comparison of this component. The potassium level appeared to have been increased slightly. However, 70 percent of the cases fell in the range 12.3–24.0 mg. per 100 ml. while the median was 21.3 mg.

TABLE 1. BLOOD SERUM VALUES FOR NORMAL COWS AND COWS SUFFERING FROM WHEAT PASTURE POISONING

	Wheat pasture poisoning cases			Normal Hereford cows			
	Range		Mean and Std. Dev.	Range		Mean and Std. Dev.	Differences in means and probable errors
	High	Low		High	Low		
Alkaline phosphatase, Bod. Units	11.5	0.6	4.23(2.11)	46.6	0.8	6.40(6.78)	2.17(0.40)
Inorganic phosphate, mg./100 ml.	13.3	1.2	4.33(2.36)	8.9	1.5	5.56(1.56)	1.23(0.22)
Total Calcium, mg./100 ml.	15.1	3.3	6.68(1.12)	12.4	9.4	11.08(0.67)	5.40(0.11)
Diffusible calcium mg./100 ml.	5.2	1.3	2.61(0.77)	5.8	3.9	4.93(0.45)	2.32(0.07)
Magnesium mg./100 ml.	3.2	0.4	1.35(0.73)	2.8	1.0	2.05(0.25)	0.70(0.07)
Potassium, mg./100 ml.	47.0	12.3	23.4 (8.3)	26.5	14.1	19.7 (2.2)	3.70(0.92)
Total protein, gm./100 ml.	10.71	6.58	8.07(0.77)	9.10	6.44	7.35(0.45)	0.72(0.07)
Albumin, gm./100 ml.	5.38	2.35	4.00(0.54)	5.20	3.67	4.38(0.24)	0.38(0.05)
Globulin, gm./100 ml.	6.14	2.82	4.11(0.70)	5.20	1.95	2.97(0.53)	1.14(0.07)
Albumin/globulin Ratio, Globulin = 1:	1.63	0.40	1.02(0.24)	2.44	0.71	1.63(0.29)	0.61(0.03)

per 100 ml. Ten percent of the levels found were over 40 mg. per 100 ml. of serum.

The decreased serum calcium levels were in good agreement with the work reported by McMillen and Langham (1942). The depressed magnesium levels conformed with the results reported on grass tetany in cattle (Sjollema and Seekles, 1930; Allcroft and Green, 1934; Muth and Haag, 1945) and in sheep (Barrentine and Morrison, 1953; Barrentine, 1953, 1954).

In addition to the values detailed in table 1, a limited number of determinations were made of the serum sugar and carbon dioxide com-

bining power during the 1949 and 1950 grazing seasons. During this same period, hematocrit, sedimentation rate, and red and white blood cell counts were made by Dr. M. R. Calliham, then Associate Veterinarian at the Laboratory. Since no significant variations were found in any of these components, no further determinations were made. The serum sodium level was determined by means of a flame spectrophotometer (Mosher, *et al.*, 1949) on 41 cases in 1953–54. The mean and standard deviation was 337.0 $\pm$ 8.3, and the range 315.6 to 370.1 mg. per 100 ml. of serum. This is in good agreement with the values found in normal cows.

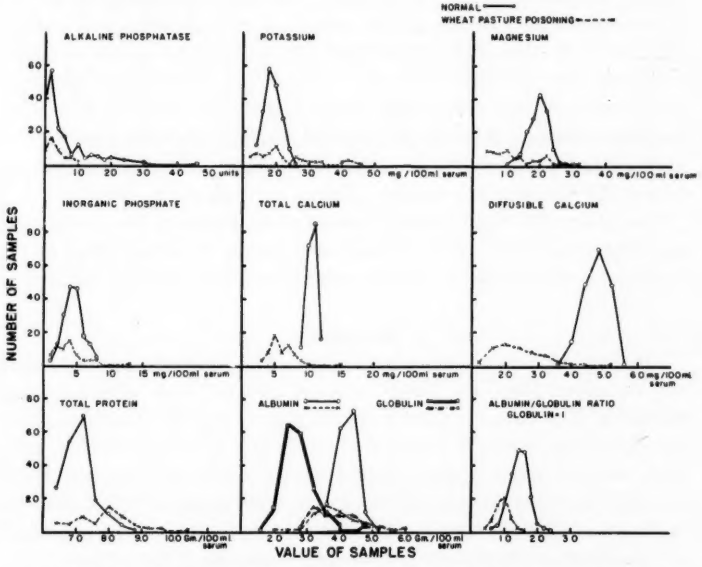

Figure 1. Frequency distribution of the various serum values.

Because of the wide range of values, frequency distribution graphs were prepared (figure 1). In addition, the significance of the differences between the means were calculated and included as part of table 1.

From the distribution data of the alkaline phosphatase, it would appear that while the normal animals had a wider range of values, the peak frequency for both normal and affected animals was at the same level of activity. Since the probable error of the difference in the means was only one-fifth of the difference, there would be some doubt as to

the significance of the difference. The possibility of a decrease in inorganic phosphate level in the affected animals was indicated. The drop in total and diffusible calcium was definitely shown by both the frequency distribution data and the difference in mean values. While different type distribution curves were found for magnesium, the higher average serum value in normal cows was confirmed by the difference in means which was ten times the probable error of the difference. In considering the potassium values, it was noted the greatest frequency for the cases was only slightly higher than the level of greatest frequency for the normals. It occurred in the same area where the second greatest frequency of normal samples was found. However, there was an extreme range of values in the cases as well as different type frequency distribution curves. Since the difference in the means was only four times the probable error, there was doubt whether the difference was significant thus confirming the frequency distribution data. The increases observed in total protein and globulin and the decreases in albumin and albumin-globulin ratio were emphasized by both the frequency distribution data and the differences in the mean values.

The rather wide range of values observed in certain of the constituents could mean that our serum findings were indicative of the effect of the condition known as wheat pasture poisoning rather than the cause.

Summary

The level of several components of the blood serum of normal cows was compared with the serum of cows affected with wheat pasture poisoning. The data revealed a decrease in inorganic phosphate, total and diffusible calcium, magnesium, and the albumin-globulin ratio, while the total serum protein, globulin, and possibly the potassium levels increased in wheat pasture poisoning. The wide range of values observed in the cases suggests that the blood serum findings could be the result of the effect of wheat pasture poisoning rather than the cause.

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SOME FACTORS AFFECTING FEED UTILIZATION IN GROWING BEEF CATTLE [1]

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INVESTIGATORS generally agree that one of the major tasks in beef production is improvement in feed efficiency. Several studies have shown that efficiency of feed utilization of various species of animals is inherited. Hess and Jull (1948), working with fowl, found a definite inherent difference in efficiency of feed utilization. Palmer *et al.* (1946) were able to establish two lines of rats for different levels of efficiency of feed utilization by selection.

In the selection of breeding animals it is important to determine their prospective value at an early age. A study of birth weight is therefore justified since it is one of the first measurements that can be obtained and also one of the easiest to record with reasonable accuracy. Knapp *et al.* (1940) have shown that birth weight is of limited value as an index of a calf's growth potentialities. Dawson *et al.* (1947), however, found that the largest calves at birth tended to reach weaning weight and slaughter weight at the youngest age. Dahmen and Bogart (1952) found that birth weight has a significant effect on both rate and economy of gain.

Age is an important factor to consider in production-testing beef cattle. As an animal increases in age and size, there are corresponding changes in the physiological functions governing the utilization and deposition of nutrients.

It is generally agreed that there are at least two components, growth and maintenance, which contribute to the utilization of feed by growing animals. It is advisable to determine maintenance requirement because it might yield valuable information concerning the problem of feed utilization. Many studies have been made to determine the energy requirement for maintenance of farm animals. It has long been recognized

[1] This study was conducted in cooperation with Bureau of Animal Industry, U. S. Department of Agriculture, and State Experiments Stations under Western Regional Project W–1 on Beef Cattle Breeding Research. Approved for publication as technical paper 886 by the Director of Oregon Agricultural Experiment Station. Contribution of the Department of Animal Husbandry.
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that some relationship exists between body size and metabolism. Brody (1945) and Kleiber (1932) have made significant contributions on this subject. Brody observed the basal metabolism of animals varying in size from mice to elephants. He found basal metabolism was proportional to the 0.743 power of the live weight. Kleiber obtained similar results.

Materials and Methods

The data used in this study were from 43 calves individually fed at the Oregon Agricultural Experiment Station under the Western Regional Beef Cattle Improvement Project. The calves were purebred Hereford and Aberdeen Angus bulls and heifers. All were produced at this station and dropped during the spring of 1952. They were weaned at 450 lb. body weight, or in the first week of December, whichever came first, and placed under experimental conditions immediately.

The animals were fed individually twice daily at uniform times and remained tied by neck chains for a total of approximately seven hours. Mangers were constructed such that calves had access to water at all times through automatic drinking cups. Pens, in which wood shavings were used for bedding, housed the calves in monosexual groups of six. The feeding period was from a weight of 500 lb. to a weight of 800 lb. The ration used has been described by Nelms *et al.* (1953). It was composed of 2 parts chopped alfalfa and 1 part concentrate, mixed thoroughly and pelleted in a one-inch pellet about one and one-half inches long. This permitted accurate determination of feed consumption. All animals were full-fed so that there was some weigh back after each feeding.

All calves were weighed each week at a uniform time, and feed consumption was calculated after each weighing.

Feed efficiency as used in this study is pounds of total digestible nutrients per pound of gain in body weight. Total digestible nutrients were determined by a digestibility trial (Nelms *et al.*, 1953).

The statistical analyses measure the within-lines and within-sex effects of three independent variables—birth weight, age-on-test, and gain-per-day during test—on the dependent variable—feed efficiency. Birth weights were taken within 12 hours after birth. Age-on-test is the age in days at which the calf reached 500 lb. Gain-per-day during test is the average gain made per day from a weight of 500 lb. to a weight of 800 lb. These analyses were carried out by the least squares analysis applying a regression model as described by Anderson and Bancroft (1952).

The regression of feed efficiency on body weight was calculated by a method similar to that presented by Titus *et al.* (1934). The correlation coefficients were calculated as outlined by Snedecor (1946). Maintenance was calculated using the method described by Brody (1945).

Results

Correlation coefficients between some traits and efficiency of gains are presented in table 1. Sex and line variations were eliminated by analyzing within sex and within lines. Aberdeen Angus were considered as one line. The coefficients of correlation (table 1) show that gains-

TABLE 1. SIMPLE CORRELATION COEFFICIENTS BETWEEN SOME TRAITS OF PUREBRED HEREFORD AND ABERDEEN ANGUS MALES AND FEMALES

	Age-on test	Birth weight	Score at 500 lb.	Score at 800 lb.	Feed intake	TDN per 100 lb. gain	
	Days	lb.			lb. TDN/week	Actual	Corrected
Males							
Gains-on test	.06	—.05	—.29	.10	.65**	—.81**	—.56*
Age-on test		—.52*	.15	.29	.46*	.28	.49*
Birth weight			.10	.14	—.23	—.12	—.23
Score at 500 lb				.41	.08	.49*	.50*
Score at 800 lb					.21	—.07	—.01
Feed intake						—.16	.22
TDN per 100 lb of gain							.90**
Females							
Gains-on test	—.31	.34	—.32	.14	.39	—.63**	—.35
Age-on test		—.58**	—.03	—.46*	.14	.42*	.42*
Birth weight			—.07	.36	—.18	—.53**	—.53**
Score at 500 lb				.64**	—.29	.08	—.15
Score at 800 lb					.01	—.09	—.08
Feed intake						.39	.69**
TDN per 100 lb of gain							.94**

* Significantly different from 0 at 5 percent level.
** Significantly different from 0 at 1 percent level.

per-day during test, age-on-test and birth weight were significantly related to efficiency of gains.

The means for birth weight, age-on-test, daily gains-on-test, TDN per unit of gain and TDN per unit of gain when corrected for maintenance are presented in table 2. When considered within lines, bulls were heavier at birth in every case than heifers; however, Hereford heifers were heavier than the Angus bulls. The Angus heifers were 11 lb. lighter at birth than the Hereford heifers (table 2).

Bulls reached 500 lb. at a younger age than did the heifers, with the exception of Line 1. Note that the Angus bulls reached 500 lb. at a

younger age than any other group even though they were lighter at birth.

Bulls gained approximately 0.70 lb. more per day than the heifers. Line 2 bulls had a lower gain-per-day than bulls of any other group. It is interesting to note some relationships in the Line 2 bulls which had the best efficiency when corrected for maintenance while they had only a mediocre efficiency based on TDN per unit of gain.

Bulls were more efficient than heifers (table 2). The efficiency figures for bulls are worthy of noting in that they required only about 4 lb.

TABLE 2. AVERAGE BIRTH WEIGHTS, AGE-ON-TEST, GAIN-PER-DAY ON TEST, TDN PER UNIT OF GAIN AND EFFICIENCY LESS MAINTENANCE OF TEST CALVES

Line and sex	No. of Animals	Average birth weights	Average Age-on test	Average daily Gain-on test	TDN per 100 lb. gain	
					Actual	Corrected
		lb.	Days	lb. per day	lb.	lb.
Line 1						
Males	8	76	233	3.12	372	241
Females	4	74	229	2.37	526	356
Line 2						
Males	3	74	220	2.43	404	238
Females	4	67	265	2.20	497	314
Line 3						
Males	1	77	246	2.75	396	257
Females	6	69	254	2.26	528	346
All Hereford						
Males	12	76	231	2.91	382	242
Females	14	70	250	2.27	518	339
Line 4 (Angus)						
Males	6	64	215	2.87	404	260
Females	11	59	264	1.95	608	403

of TDN per pound of gain, while heifers required more than 5 lb. of TDN per pound of gain.

Line 1 bulls and heifers were outstanding in almost every case. They were heavier at birth, had less than average age-on-test and had higher gain-per-day. The Angus heifers stand out also; they were lighter at birth, older at 500 lb. body weight, had a lower gain-per-day, and were less efficient than any other group of animals.

Effects of Birth Weight, Age-on-Test and Gain-per-Day During Test on Efficiency Within Sex and Within Lines

The summary of the analysis of variance is presented in table 3. The partial regression coefficients of the independent variables and their confidence intervals are presented in table 4.

TABLE 3. SUMMARY OF ANALYSIS OF VARIANCE

Source of variation	d.f.	Efficiency	
		Actual	Corrected
		M.S.	M.S.
Sex	1	6,427**	4,927*
Line	3	4,849**	4,570**
Line × sex	3	306	377
Regression on:			
Birth weight	1	3,773**	3,532*
Age on test	1	3,351	3,823*
Rate of gain	1	41,844**	11,357**
Error	32	842	759
Total***	42	7,086	3,846

* Significant at 5 percent level.
** Significant at 1 percent level.
*** The sums of squares do not add to the total because of non-orthogonality in the design.

The difference in efficiency between Line 2 and the remaining lines, as indicated in table 2, was significant. Also the sex difference noted in table 2 was significant. The calculated partial regression coefficients (table 4) of efficiency on the three continuous independent variables (birth weight, age-on-test and gain-on-test) indicate that all three have a significant effect on efficiency of feed utilization in all cases with the exception of the effect of age-on-test on efficiency based on TDN per unit of gain.

The biological implications of the regressions are as follows:

1. For each increase in birth weight of 10 lb. there is a reduction of 16 lb. in TDN per 100 lb. gain when based on efficiency corrected for maintenance, and a reduction of 17 lb. in TDN per 100 lb. gain when based on uncorrected efficiency.

TABLE 4. PARTIAL REGRESSION COEFFICIENTS OF EFFICIENCY ON BIRTH WEIGHT, AGE-ON-TEST, GAINS-ON-TEST, INDEPENDENT OF LINE AND SEX EFFECTS (PARTIAL REGRESSION COEFFICIENT AND THE 95 PERCENT CONFIDENCE INTERVAL)

	TDN per 100 lb. gain	
	Actual	Corrected
Birth weight	— 1.68* ± 1.62	— 1.63* ± 1.50
Age-on-test	.40 ± .41	.42* ± .39
Gains-on-test	—124.06* ± 35.91	—64.63* ± 38.13

* Significantly different from 0 at 5 percent level.

2. For each increase in age-on-test of 10 days there was an increase of 4.2 lb. in TDN per 100 lb. gain when feed efficiency is corrected for maintenance. The regression coefficient of uncorrected feed efficiency on age-on-test is not quite significant.

3. For each increase in gain per day of 1 lb. there is a saving of 124 lb. in TDN per 100 lb. gain based on uncorrected efficiency and 65 lb. in TDN per 100 lb. gain when efficiency is based on TDN requirement corrected for maintenance.

The coefficients of determination, $R^2 = 0.90$, for efficiency corrected for maintenance, and $R^2 = 0.94$, for TDN per unit of gain, means that 90 and 94 percent respectively of the variations in efficiency are accounted for by variations in the three independent variables used.

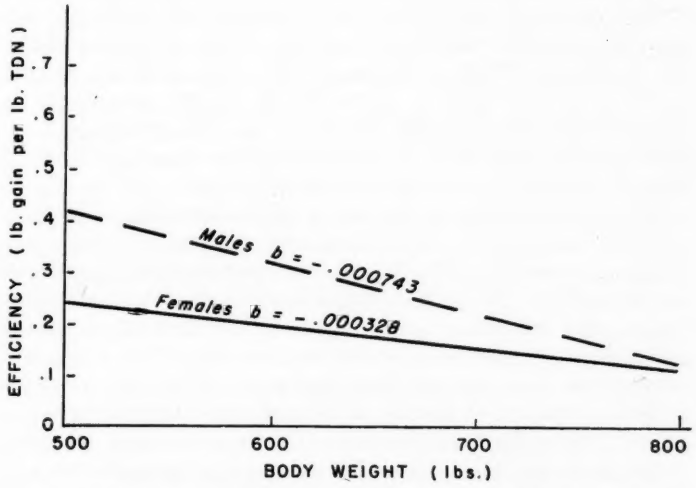

Figure 1. The regression of efficiency on body weight.

Effects of Increased Weight on Efficiency

Efficiency was calculated as gains per unit of TDN and regressed on body weight for males and females within lines, and these results are presented in figure 1.

It can be seen that the males decrease in efficiency at a much greater rate than do females. The regression of —.000328 of feed efficiency on body weight for the females indicates that an increase in live weight of 100 lb. is associated with a reduction of 3.28 lb. of gain which results

from each 100 lb. TDN consumed. The regression of —.000743 of feed efficiency on body weight of males indicates that an increase of 100 lb. in body weight is associated with a decrease of 7.43 lb. in gains made from each 100 lb. TDN consumed. It can be seen (figure 1) that even though the males decreased in efficiency faster they are still more efficient than the heifers at 800 lb. body weight.

Discussion

A high score on bulls at 500 lb. body weight is associated with a high TDN requirement during the feed test. This means that a rancher may be culling the more efficient bulls at weaning time since culling is done largely on the basis of score at that time.

In the case of the heifers there was a significant negative correlation between age-on-test and score at 800 lb. body weight and a lack of a significant correlation between score at 500 lb. body weight and age-on-test. This suggests that the "better-doing" calves during the suckling period are not the "better-looking" calves at 500 lb., probably due to type of growth which is largely skeletal and muscular at that age. However, the calves doing better in early life have the stimulus to do better later and in turn to look better at a heavier weight.

In the case of bulls there is a lack of significant correlation of scores at 500 lb. with scores at 800 lb., while for heifers these two scores were significantly correlated. This may indicate that the heifers look more nearly mature at 500 lb. body weight than do the bulls. The significant negative correlation between 500 lb. score and TDN per unit of gain in the bulls may indicate that the bulls which have a tendency to lay on fat at an early age (and consequently score higher) are less efficient. In the case of females, all probably have started fattening at 500 lb. body weight since the score at this weight is highly correlated with score at 800 lb. body weight. The positive correlation between feed intake and TDN per unit of gain corrected for maintenance in the case of heifers might be expected, because the increase in feed intake takes place faster than efficiency decreases.

The negative correlation between age-on-test and birth weight might be expected because it has been shown that larger calves at birth reach weaning size at a younger age (Sawyer *et al.*, 1949; Gregory *et al.*, 1950; Kohli *et al.*, 1951; Galgan *et al.*, 1952; Dahmen and Bogart, 1952; and Pierce *et al.*, 1953). Also, female calves which were heavier at birth were significantly more efficient during the performance test.

Cow size has been quite well established as one of the important

factors affecting birth weight of calves; Gregory *et al.* (1950) and Knapp *et al.* (1940). Since the calf retains this advantage to maturity, it appears that the importance of birth weight as a factor in beef cattle improvement through selection can hardly be over-emphasized.

The correlation analysis reveals that age-on-test was related to TDN per unit of gain. The older calves at 500 lb. were less efficient. This is contrary to results by Dahmen and Bogart (1952). In the present study, the effect of age-on-test can probably be explained by the fact that pasture conditions were better than in most cases, thus producing a good milk flow from the dams. Therefore, the calves that made the best growth during the suckling period continued to do so during the performance test and were also more efficient. Thus, the calves in the present study were expressing their genetic capacity for growth both prior to and following weaning.

Gain per day during the test had a significant effect on efficiency. The faster gaining calves were the most efficient. This has been shown to be true by numerous investigations.

This study is in harmony with the findings of Blackwell (1952) and Dahmen and Bogart (1952) that males are more efficient than heifers at the same body weight. Because of this large sex difference it seems unfair to compare the progeny of one sire with that of another, unless comparisons are made within sex. The fact that heifers were less efficient than bulls indicates that the gains were not the same type of tissue. There was little difference in feed consumption, yet the difference in gains was tremendous.

It appears that calves of Line 2 had low metabolic rates and were efficient in spite of the lower food intake and reduced rate of gain. According to Kleiber (1936) the rate of production of body substances in growing animals depends on the stimulus for growth and on the level of available energy. With a greater stimulus for growth which is apparent in Line 2, rate and efficiency can be high even with moderate food intake.

Conclusions

1. Bull calves decrease in efficiency more rapidly than heifers from body weights of 500 lb. to 800 lb. However, bulls continue to be more efficient than heifers at 800 lb. body weight.

2. Heavier calves at birth were more efficient during the test.

3. Age-on-test affected efficiency when corrected for maintenance, with younger calves being more efficient. There is some indication that age-on-test is associated with uncorrected efficiency.

4. Faster gaining calves utilized feed more efficiently than calves gaining less rapidly.

5. Line 2 animals were more efficient but gained at a slower rate than the animals of the other lines tested. There was no difference between any two of the remaining lines.

6. From 90 to 94 percent of the variations in feed efficiency are accounted for by variations in birth weight, age-on-test, and rate of gain.

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GENETIC AND ENVIRONMENTAL RELATIONSHIPS AMONG ECONOMIC CHARACTERS IN BEEF CATTLE

III. EVALUATING MATERNAL ENVIRONMENT [1, 2]

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THE methods used in estimating the heritability of traits and the genetic correlations among them depend on the resemblance of relatives as compared to unrelated individuals. Some of the more common relationships studied are the correlations among half-sibs, full-sibs, and parent and offspring. The theory of inheritance governs the relationships between the genetic values of relatives. By comparing the observed correlations between relatives with the theoretical composition, we can ordinarily determine heritability. However, some traits involve relationships which are not so easily separated, as for example, traits which are influenced by maternal environment. In beef cattle, the cow influences such traits as birth weight and gain from birth to weaning, both by the genes she transmits and by the maternal environment she provides. Because of the maternal environment provided by the cow, the correlations between maternal half-sibs arise from different causes than those between paternal half-sibs. Similarly, the correlations between offspring and dam have a different expectation from those between offspring and sire. One of the difficulties of partitioning the maternal influence into that portion affected by genes transmitted and that affected by maternal environment is that no direct measurement of maternal environment can be made. General statements about the influence of maternal environment can be inferred from general observations. Also, we can compare the correlations observed in the various types of relationships, that is maternal versus paternal half-sibs, offspring-dam, and offspring-sire, with the theoretical expectations. Except for sex-linked genes, the genetic relationships among different traits in the same animal would be the same for maternal and paternal relatives.

In previous papers (Koch and Clark, 1955a, 1955b) the correlations

[1] Contribution from the Western Regional Project W–1, "The Improvement of Beef Cattle Through Breeding Methods."
[2] Acknowledgment is made to Superintendent J. R. Quesenberry, U. S. Range Livestock Experiment Station, Miles City, Montana, under whose supervision the data for this study were collected in cooperation with the Montana Agr. Exp. Sta.
[3] Department of Animal Husbandry, University of Nebraska, Lincoln.

between maternal and paternal half-sibs, and the correlations between offspring and parents were presented. This paper seeks to compare the theoretical composition of these correlations with the observed values and to estimate the influence of maternal environment from them.

Analysis of Data and Results

Paternal Half-Sib Correlations

The correlations between paternal half-sibs are presented in table 1 and again diagramatically as a path coefficient diagram in figure 1.

TABLE 1. GENETIC, ENVIRONMENTAL, AND PHENOTYPIC CORRELATIONS AMONG PATERNAL HALF-SIBS

		Wn. wt.	Gain B.-wn.	Wn. score	Yrlg. wt.	Gain Wn.-yrlg.	Yrlg. score
Birth	Genetic	.63	.46	.19	.40	.06	.13
weight	Environ.	.29	.12	.19	.30	.03	.23
	Pheno.	.39	.21	.19	.34	.04	.20
Weaning	Genetic		.98	.47	.54	—.03	.23
weight	Environ.		.99	.68	.46	—.47	.27
	Pheno.		.98	.64	.47	—.33	.26
Gain	Genetic			.50	.51	—.05	.23
b.-wn.	Environ.			.67	.43	—.49	.25
	Pheno.			.64	.44	—.36	.24
Weaning	Genetic				.31	.05	.45
score	Environ.				.25	—.39	.26
	Pheno.				.25	—.26	.29
Yrlg.	Genetic					.83	.49
weight	Environ.					.56	.61
	Pheno.					.67	.56
Gain	Genetic						.44
wn.-yrlg.	Environ.						.35
	Pheno.						.38

The genic value of the sire for a given trait is represented by G_i' and the corresponding value in the offspring by G_i. The E_i''s represent the environmental influences. The dominance and most of the epistatic deviations for half-sibs are not correlated but act similar to environmental variations and are included with the E_i's. The P_i's are the phenotypic expressions of the various traits, the net result of G_i and E_i. The diagram is shown with the genotype for maternal environment although there is no phenotypic expression of maternal environment in the sire or the offspring for the traits considered. The path coefficients measure, in

terms of standard deviations, the direct influence of the various factors in causing changes in the dependent variable. The square of a path coefficient measures the portion of the variation in the dependent variable that is determined directly by the causal factor. Thus, the square

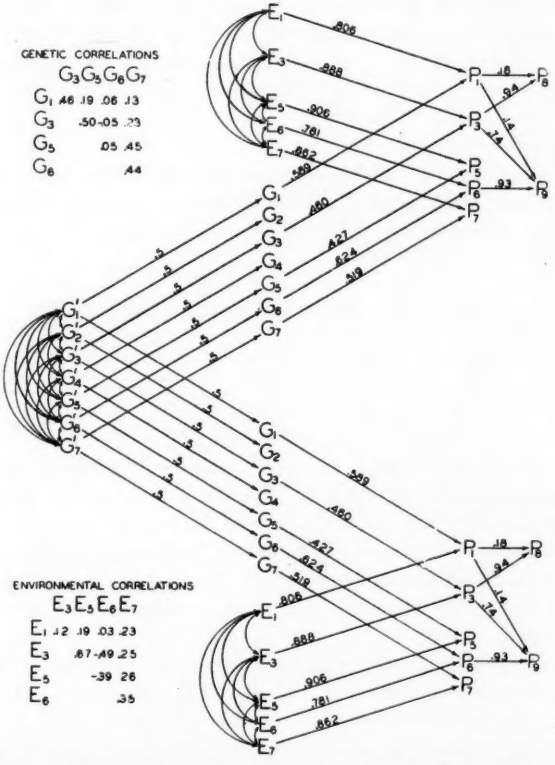

Figure 1. Relationships among paternal half-sibs. 1, birth weight; 2, prenatal maternal environment; 3, gain from birth to weaning; 4, maternal environment from birth to weaning; 5, weaning score; 6, yearling gain; 7, fall yearling score; 8, weaning weight; 9, fall yearling weight.

of the path from G to P represents the fraction of the phenotypic variance that is determined directly by the additively genetic variance, that is, heritability in the narrow sense. The double headed arrows represent residual correlation between the genetic or environmental factors. The

genetic correlations in the offspring are the same as in the sire, but are omitted for clarity in the diagram. The correlation between any two variables can be readily obtained by summing the products along all of the paths connecting the variables. For example, the phenotypic correlation between weaning gain and weaning score of .64 is the summation of paths along the genetic chain ($.460 \times .50 \times .427 = .10$) and the environmental contribution ($.888 \times .67 \times .906 = .54$). Other relationships may be similarly derived. The correlation between the birth weights of paternal half-sibs is $.25\ (.589)^2 = .087$.

Maternal Half-Sib Correlations

The relationships among maternal half-sibs differ from those of paternal half-sibs because of the additional influence through the maternal environment provided during the prenatal and preweaning periods.

TABLE 2. MATERNAL HALF-SIB CORRELATIONS

Birth wt.	Wn. wt.	Gain b.-wn.	Wn. score	Yrlg. wt.	Gain wn.-yrlg.	Yrlg. score
.26	.34	.34	.22	.20	.09	.02

The correlations between maternal half-sibs are presented in table 2 and diagramatically in figure 2. The symbolism, genetic correlations, and the numbering of the traits are the same as in figure 1. PE_2' and PE_4' represent permanent environmental influences affecting prenatal and preweaning maternal environment. Environmental conditions could not be calculated because of the complications caused by maternal environment.

The environmental effects on birth weight are the sum of the effects from conception until the calf is weighed following birth. The calf is in an intra-uterine environment provided by the cow most of this period. In a sense, all prenatal environmental variation is variation in maternal environment. However, many of these influences vary from one calf to the next, while others seem to be a permanent characteristic of the cow causing the same influence from one calf to the next. These latter effects are the constant or permanent differences between cows which make up the variations in maternal environment referred to here. These variations may result from such things as physical differences in size, differences in ability to provide nutritive materials to the developing fetus, or any other permanent functional difference that affects prenatal growth. From the data presented in table 2 and figure 2 the correlation

between birth weights of maternal half-sibs equals $.087 + m_1^2g_2^2 + m_1^2p_2^2 + .589\, m_1g_2\, r_{G_1G_2} = .26$. The .087 represents the direct determination of variation in birth weight by additively genetic differences in the genes the calves have that influence growth response until birth.

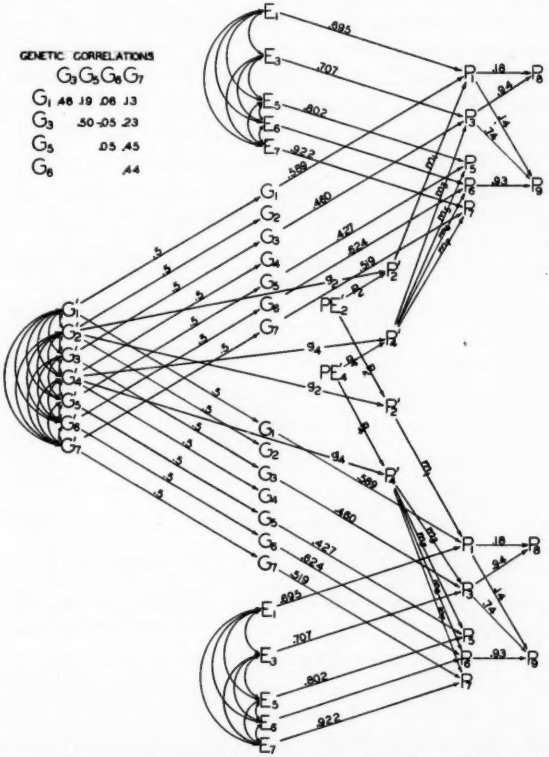

Figure 2. Relationships among maternal half-sibs. 1, birth weight; 2, prenatal maternal environment; 3, gain from birth to weaning; 4, maternal environment from birth to weaning; 5, weaning score; 6, yearling gain; 7, fall yearling score; 8, weaning weight; 9, fall yearling weight.

The $m_1^2g_2^2$ represents the direct determination by genic differences in maternal environment. The $m_1^2p_2^2$ is the direct determination by permanent environmental differences in maternal environment. The sum $m_1^2g_2^2 + m_1^2p_2^2 = m_1^2$, the direct determination by maternal environment, because $g_2^2 + p_2^2 = 1$. The $.589\, m_1g_2\, r_{G_1G_2}$ is the joint deter-

mination by the genes of the calf and the maternal environment provided by the cow. If the genotype for prenatal growth were independent of the genotype for maternal environment, $m_1^2 = .172$. Without further knowledge of the values for g_2^2, p_2^2, or $r_{G_1G_2}$ these data tell us only that differences in maternal environment likely have considerable effect on the birth weights of calves.

The maternal environment for gain from birth to weaning is more easily understood than that of birth weight. The most obvious feature of maternal environment is the milk supplied by the cow, including the way the cow cares for her calf, protecting and nourishing it at the proper time. It would seem that differences in milking ability are the most important element in maternal environment, since milk is the major source of nutrients for the calf during the early months of growth.

TABLE 3. CORRELATIONS BETWEEN TRAITS IN THE DAM AND TRAITS IN THE CALF

	Traits of the dam						
Traits of the calf	Birth wt.	Wn. wt.	Wn. gain	Wn. score	Yrlg. wt.	Yrlg. gain	Yrlg. score
Birth wt.	*.23*	.16	.10	.07	.21	.14	.04
Wn. wt.	.03	*.06*	.05	.01	.12	.11	.12
Wn. gain	−.01	.03	*.04*	−.01	.09	.09	.01
Wn. score	.03	.04	.03	*.08*	.13	.13	.10
Yrlg. wt.	.03	.15	.15	.12	*.23*	.17	.04
Yrlg. gain	.01	.11	.12	.13	.15	*.10*	.03
Yrlg. score	.01	.06	.06	.16	.04	.00	*.08*

The maternal half-sib correlation for weaning gain equals $.053 + m_3^2g_4^2 + m_3^2p_4^2 + .460\ m_3g_4r_{G_3G_4} = .34$. The determination by the various sources is similar to that described for birth weight.

Maternal environmental factors which increase gain would also affect weaning score favorably. The calves that gain well and carry more condition were naturally given better scores than the calves that were their equal so far as basic conformation was concerned but did not have the opportunity to develop as well. The maternal half-sib correlation for weaning score equals $.046 + m_5^2g_4^2 + m_5^2p_4^2 + .427\ m_5^2g_4^2\ r_{G_4G_5} = .22$. The expectations for yearling gain and score can be similarly set out.

Correlation Between Offspring and Dam

The correlations between offspring and dam for the various traits are presented in table 3 and figure 3. As in the case of maternal half-sibs, the correlation between offspring and dam has the added relationship

through maternal environment. The relationships between dam and offspring differ from those involved in maternal half-sibs in that additional terms through the maternal grandam exist for offspring and dam while relationships through permanent environmental sources are absent. Figure 3 is the path coefficient diagram illustrating the relationships involved in the correlation of offspring and dam. In order to simplify

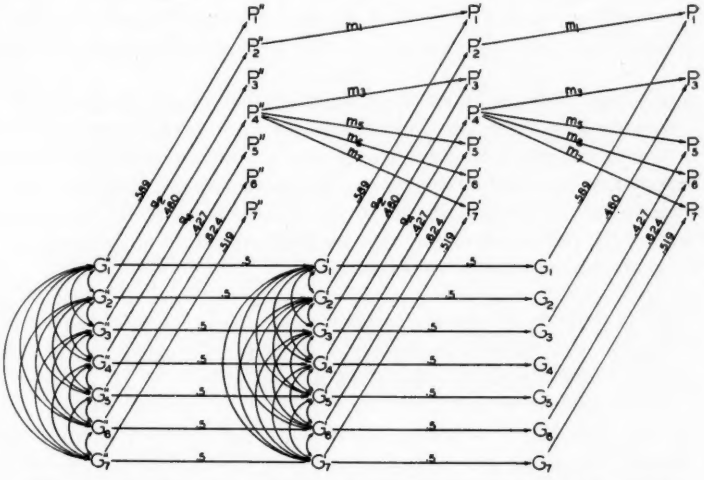

Figure 3. Relationships between offspring, dam, and maternal grandam. 1, birth weight; 2, prenatal maternal environment; 3, gain from birth to weaning; 4, maternal environment from birth to weaning; 5, weaning score; 6, yearling gain; 7, fall yearling score.

the diagram, the paths for the environmental influences are not shown. Their influence would be the same as among maternal half-sibs. The genetic correlations and the numbering of the traits are the same as in figure 1. The G_i and P_i values are those of the offspring, the G_i' and P_i' are for the dam, and the G_i'' and P_i'' are for the maternal grandam. For example, the correlation between the birth weight of the dam and the birth weight of the daughter is

$$r_{P_1P_1} = \frac{.34}{2} + .589\, m_1 g_2 r_{G_1G_2} + \frac{.589\, m_1 g_2 r_{G_1G_2}}{4} + \frac{m_1^2 g_2^2}{2} = .234.$$

The $\frac{.34}{2}$ is the correlation due to the calf receiving half its genes from the dam. The $\frac{.589\, m_1 g_2 r_{G_1G_2}}{4}$ expresses the evidence provided by the

TABLE 4. CORRELATIONS BETWEEN TRAITS IN THE SIRE AND TRAITS IN THE OFFSPRING

Traits in the offspring	Traits in the sire			
	Birth wt.	Wean. wt.	Gain b.-wn.	Wn. score
Birth wt.	.18	.11	.08	.02
Wean. wt.	.17	.13	.11	.03
Gain, b.-wn.	.12	.11	.09	.03
Wean. score	.11	.10	.09	.08

dam's own birth weight on the probability that genes which affected both maternal environment and birth weight in the grandam were transmitted to the granddaughter. The $m_1^2 g_2^2/2$ term expresses the direct influence of maternal environment. The halving results from the fact that we cannot measure the maternal environment directly but must rely on the phenotype of the dam for birth weight as an indicator of the genes she has for maternal environment.

Correlation Between Offspring and Sire

The correlations between several traits in the sire and traits in the offspring are presented in table 4 and figure 4.

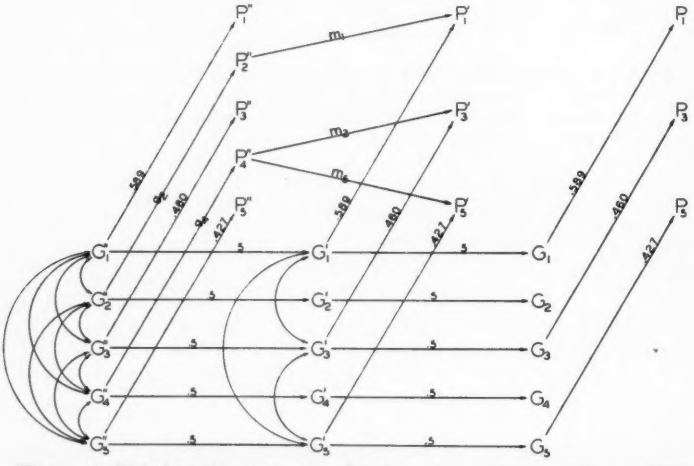

Figure 4. Relationships between offspring, sire, and paternal grandam. 1, birth weight; 2, prenatal maternal environment; 3, gain from birth to weaning; 4, maternal environment from birth to weaning; 5, weaning score.

The phenotype of the sire is correlated with the phenotype of the offspring both through the genes transmitted to the offspring affecting a given trait, and through influence of the maternal environment of the paternal grandam. The path coefficient diagram in figure 4 illustrates the relationships. In this diagram the G_i and P_i values are those of the offspring, the G_i' and P_i' are for the sire, and the G_i'' and P_i'' are for the paternal grandam. The genetic correlations and the numbering of the traits are the same as in figure 1. The external environmental influences are omitted from the diagram for clarity of presentation.

The contribution of maternal environment to the correlations between offspring and sire is shown in the following example involving weaning gain.

$$r_{P_3P_3'} = \frac{g_3^2}{2} + \frac{m_3 g_3 g_4 r_{G_3G_4}}{4} = .106 + .115\, m_3 g_4 r_{G_3G_4}$$

Evaluating Maternal Environment

As mentioned before, the relationships involving maternal environment cannot be specified because there is no direct measure of them. The relationships between maternal half-sibs, offspring and dam, and offspring and sire contain these influences while the paternal half-sib correlations do not. By comparing the relationships derived from these methods it is possible to find values for the various paths which satisfy the observed correlations. Of particular interest are the genetic correlations between maternal environment and the other traits. From figure 2 the correlation between the phenotypes of maternal half-sibs for any trait is of the form $r_{P_iP_i} = .25\, g_i^2 + m_i^2 g_m^2 + m_i^2 p_i^2 + m_i^2 g_m^2 g_i r_{G_iG_m}$, where g_i^2 is the heritability of the i^{th} trait, m_i^2 the direct determination by maternal environment, g_m^2 the heritability of maternal environment, p_i^2 the direct determination of maternal environment by permanent environment factors, and $r_{G_iG_m}$ the genetic correlation between the i^{th} trait and maternal environment. Similarly from figure 3 the correlation between offspring and dam is $r_{P_iP_i'} = .5 g_i^2 + .5\, m_i^2 g_m^2 + 1.25\, m_i g_m g_i r_{G_iG_m}$ if E_2 and E_4 are independent of the other E's. The correlation between paternal half-sibs as shown by figure 1 is $r_{P_iP_i} = .25\, g_i^2$. From the maternal half-sib correlation, $r_{G_iG_m} = \dfrac{r_{P_iP_i} - m_i^2 g_m^2 - m_i^2 p_i^2 - .25\, g_i^2}{m_i g_m g_i}$. From the correlation between offspring and dam, $r_{G_iG_m} = \dfrac{r_{P_iP_i'} - .5\, g_i^2 - .5\, m_i^2 g_m^2}{1.25\, m_i g_m g_i}$.

Because the values for $r_{G_iG_m}$, g_i^2, g_m^2, and m_i^2 are the same in the popu-

lation, the values for $r_{G_1C_m}$ can be equated. This yields $.75\ m_i^2 g_m^2 + 1.25\ m_i^2 p_i^2 = 1.25\ r_{P_1P_1} - r_{P_1P_1'} + .1875\ g_i^2$. The estimates for $r_{P_1P_1}$, $r_{P_1P_1'}$, and g_i^2 found in the maternal half-sib, regression of offspring on dam, and paternal half-sib analyses, respectively, can be substituted in the equation to reduce the number of unknown values. The values from the regression of offspring on sire were not used here because of the relatively small amount of data available for computing them.

The m_i^2, g_m^2, and p_i^2 values are not known but various probable values can be assumed for two of them and limits established within which the third may be expected to fall. The genetic correlations that are compatible with the three analyses can be obtained for the various values of m_i^2, g_m^2, and p_i^2. Let g_m^2 in turn take on the values of .09, .16, .25, .36, .49, and .64. Let p_i^2 have the values of .09, .25, and .49. Then for each level of g_m^2 and p_i^2, m_i^2 is evaluated by the equation

$$m_i^2 = \frac{1.25\ r_{P_1P_1} - r_{P_1P_1'} + .1875\ g_i^2}{.75\ g_m^2 + 1.25\ p_i^2}$$

and $r_{G_1C_m}$ is determined by substituting in either of the equations derived earlier.

TABLE 5. GENETIC CORRELATIONS BETWEEN MATERNAL ENVIRONMENT AND BIRTH WEIGHT FOR VARIOUS VALUES OF g_2^2, p_2^2 AND m_1^2

Values of p_2^2		Values of g_2^2					
		.09	.16	.25	.36	.49	.64
.09	m_1^2	.86	.66	.52	.40	.32	.26
	$r_{G_1G_2}$	.11	.03	−.01	−.04	−.06	−.08
.25	m_1^2	.41	.36	.31	.27	.23	.20
	$r_{G_1G_2}$	.30	.18	.11	.06	.02	−.01
.49	m_1^2	.23	.21	.19	.18	.16	.14
	$r_{G_1G_2}$	.48	.32	.22	.16	.11	.07

The values of m_1^2 and $r_{G_1G_2}$ at various levels of g_2^2 and p_2^2 for the case of birth weight are given in table 5. If the heritabilities for other traits studied here are any guide, the most probable range for g_m^2 would be between .16 and .49. Over the range of probable values for g_2^2 and p_2^2 the direct influence of maternal environment (m_1^2) is quite large. The genetic correlation between maternal environment for birth weight and the genic value for birth weight is likely to be a small positive value unless heritability is high and permanent environmental factors are

negligible. In that case the genetic correlation may be a low negative value.

The relationships for gain from birth to weaning were worked out similarly and are presented in table 6. In this case the maternal environment appears more important over all the range of g_4^2 and p_4^2 than in the case of birth weight. The genetic correlations are all large negatives ranging from —.65 to —.77. There is more evidence for judging the most probable values of g_4^2 and p_4^2 in the case of weaning weight than for birth weight. Knapp and Black (1941) reported that milk consumption of the Shorthorn calves studied was the most important influence found on gain from birth to weaning. They observed a correlation of .52 between quantity of milk consumed and gains made by the calves. Gifford (1953) reported correlations in Hereford cows ranging from .71 to .19 between the monthly milk production of the cows and the .65 between total milk production of the cow and gain of the calf up to

TABLE 6. GENETIC CORRELATIONS BETWEEN MATERNAL ENVIRONMENT AND WEANING GAIN FOR VARIOUS VALUES OF g_4^2, p_4^2, AND m_3^2

Values of p_4^2		Values of g_4^2					
		.09	.16	.25	.36	.49	.64
.09	m_3^2	2.42	1.87	1.45	1.14	.91	.73
	$r_{G_3G_4}$	—.67	—.70	—.72	—.75	—.76	—.77
.25	m_3^2	1.14	1.00	.87	.75	.64	.55
	$r_{G_3G_4}$	—.66	—.65	—.67	—.68	—.70	—.72
.49	m_3^2	.64	.59	.54	.49	.44	.40
	$r_{G_3G_4}$	—.71	—.66	—.65	—.65	—.67	—.68

six months of age. There are no published accounts on the heritability of milk production in beef cattle. Most estimates on heritability of milk production in dairy cattle range from .16 to .35. The reports on repeatability of milk production range from .25 to .50. Assuming that heritability is about .2 and repeatability about .4 the direct determination from permanent environmental sources (p_4^2) is $.4 - .2 = .2$.

The heritability and repeatability of milk production in dairy cattle are the best indications of these same relationships in beef cattle. Assuming that milk production is equivalent to the maternal environment provided the calf from birth to weaning, the most probable values for the direct determination by maternal environment range from 1.00 to .75.[4]

[4] Path coefficients, unlike correlation coefficients, can have values greater than 1.00.

The corresponding genetic correlation between maternal environment and the genes conditioning growth response from birth to weaning range from —.65 to —.68.

The relationships involving maternal environment and weaning score were evaluated similarly. As in the case of weaning gain, the genetic correlations between maternal environment and weaning score are negative over all the range of values for g_4^2 and p_4^2. The direct influence of maternal environment was large, but only about half as large as in the case of weaning gain. Since the maternal environment affecting weaning score is the same environment as that considered for weaning gain, the most probable values of g_4^2 and p_4^2 are as before .16 to .35 and .2, respectively. In this range a negative genetic correlation of the order of —.32 to —.39 exists between weaning score and the maternal environment provided from birth to weaning. The corresponding range of values for the direct influence of maternal environment (m_5^2) was .53 to .39.

In the case of gain from weaning until fall yearling age and yearling score, the maternal environment is not a direct influence in the sense of providing nourishment or care, but it may be influential through the carry-over effects of gains directly influenced by the maternal environment during the preweaning period. The general nature of the carry-over effects of maternal environment seems closely allied to the situation among cattle that are fed at different nutritional levels for a period and subsequently have their feed equalized. The cattle on lower levels of feed during the first period generally gain more during the second period than the cattle that were fed at higher levels. For example, steers fed to gain well during the winter do not gain as much the following summer as steers fed to maintain their weight or to gain only a little. In the case of yearling gain the differences in milking ability of cows cause differences in the feed supply of calves during the preweaning period. During the postweaning period when the feed supply among calves is equalized, the calves from poor milking cows would be expected to gain more rapidly than genetically comparable calves that had better milking dams. From this it would seem that the direct influence of maternal environment is likely to be negative. Even though the relation is negative it would still tend to increase the likeness of maternal half-sibs because they would deviate in the same direction.

An evaluation of maternal influence and the genetic correlation between yearling gain and maternal environment yielded positive correlations over the entire range of values used. The maternal environment is the same environment that influenced weaning gain. For the most

probable values of heritability of maternal environment the direct influence of maternal environment (m_6^2) ranged from .14 to .20 and the genetic correlation between maternal environment and yearling gain ranged from .7 to .8.

A similar analysis for yearling score yielded extremely low values for the direct influence of maternal environment and unrealistic values (over 1.0) for the correlation of maternal environment and yearling score.

Discussion

Maternal influence

The maternal influence of cows on the phenotypic expression for traits in the calf is due to genes transmitted by the cow to the calf and by the maternal environment provided during part of the calf's life. The contribution of the cow from genes transmitted is the same as that of the sire except for sex-linked genes. The relationships among paternal half-sibs can be used as a measure of maternal influence from this source. The influence through maternal environment appears in two phases of the calf's life. The first phase is the intra-uterine period from conception until birth. The second phase is from birth to weaning.

Maternal environment cannot be measured directly. Its influence can only be inferred from observation and comparison of relationships where the effect is included with those where the effect is excluded. Estimates of the influence of maternal environment and of the genetic correlations between it and the other traits were obtained by comparing the theoretical composition of the offspring-dam, maternal half-sib, and paternal half-sib correlations with the observed values. Point estimates were not obtained because the number of unknowns exceeded the equations for estimating them. Instead, a range of values was determined for various probable values of the influences. One of the most interesting observations was that the maternal environment from birth to weaning appears negatively correlated, genetically, with weaning gain and score over the entire range of probable values. Even if allowance were made for considerable error, negative genetic correlations are indicated. There are no similar studies in beef cattle to compare these results with. However, in dairy cattle, Touchberry (1950) reported a genetic correlation of —.53 between body weight and milk production of Holstein cows. Dickerson (1947) and Dickerson and Grimes (1947) suggested that suckling ability in swine was negatively correlated, genetically, with efficiency of gain and to a lesser extent with rate of gain.

Let us consider the consequences of selection if in fact there is a nega-

tive genetic correlation between maternal environment or milking ability and growth response from birth to weaning. The regression of genic value for growth response to weaning (G_3) on phenotypic value for weaning gain (P_3) is $g_3^2 + .5\ g_3g_4m_3\ r_{G_3G_4}$. The regression of genic value for maternal environment (G_4) on phenotypic value for weaning gain (P_3) is $.5\ g_4^2m_3^2 + g_3g_4m_3\ r_{G_3G_4}$. The regression of total genic value affecting weaning gain ($G_3 + G_4$) on phenotypic value for weaning gain is the sum of these two regressions. From table 6 let the value of $m_3^2 = .87$, $g_4^2 = .25$, $r_{G_3G_4} = -.67$. From the paternal half-sib correlations let $g_3^2 = .21$. Then $b_{G_3P_3} = .21 - .072 = .138$, $b_{G_4P_3} = .109 - .143 = -.034$, and $b_{(G_3+G_4)} = .138 - .034 = .104$. In selecting calves on the basis of their weaning gains we will be selecting for better genic values in growth response. Part of the genetic gain made in growth response is nullified by the fact that some of the genes which affect growth response favorably have an adverse effect on milking ability. Selecting for weaning gains will also result in some improvement in genotypes for milking ability, but this increase is more than offset, so far as observed gain is concerned, by loss in growth response due to genes that affect milking ability favorably and growth response unfavorably. The total gain in actual weight from genetic value ($G_3 + G_4$), though positive, is far less than would be the case if they were independent or positively correlated. Selection under a management system where differences in milking ability of the dam are made less important, such as creep feeding the calves, favors the genic value for growth response at the expense of the genic value for milking ability. However, as long as differences in milking ability are of any importance in increasing weaning gain there will be some selection for better milking ability if selection is based on weaning gain. Suppose that cattle were managed in such a manner that differences in the milking ability of cows were of no importance, as when calves are placed on nurse cows. Selection on the basis of weaning gain would be entirely for growth response and, due to the negative genetic correlation, will result in a loss of genic value for milking ability.

The weaning gain of the calf is our best measure of the milking ability of the cow. The value of the calf's weaning gain as an indicator of the dam's genic value for milking ability is given by the regression of G_4' on P_3 which equals $g_4^2m_3^2 + .5\ g_3g_4m_3\ r_{G_3G_4} = .218 - .072 = .146$. The regression of the cow's genic value for growth response (G_3') on P_3 is $.5\ g_3^2 + g_3g_4m_3\ r_{G_3G_4} = .105 - .143 = -.038$. The regression of total genic value of the cow on weaning gain of the calf is $.146 - .038 =$

.108. Selecting cows which produce heavy calves would place greater emphasis on milking ability than on growth response so far as the genic values of the cows are concerned.

Similarly the results of selecting calves on the basis of their weaning score would lead to increased genic value affecting weaning score directly and to a lesser extent genic value for maternal environment affecting weaning score. Part of the increased genic value for the direct effects of each would be lost because some of the genes which affect weaning score favorably have adverse effects on milking ability. Selection of cows which have high scoring calves places more emphasis on milking ability than does selection of the calves on the basis of their own scores.

Selecting heifers on the basis of yearling gain leads to increased genic value for growth response from weaning until fall yearling age. Part of the genic improvement is lost because milking ability, which has a negative direct influence, is positively correlated with genes for yearling growth response. Selecting for yearling gain causes a decline in the genic value of milking ability, but the effects of the decline in genic value for milking ability on actual gain are more than offset by the release from the direct negative effect that milking ability has on yearling gain.

From the above discussion it would seem that if the negative correlations postulated actually exist, more emphasis should be placed on selecting cows on the basis of their calf's weaning weights and scores if selection for milking ability is to keep pace with selection for growth response. In fact if extreme emphasis were placed on calf gains alone, particularly on yearling gain, we could actually suffer a loss in genetic value for milking ability.

Genetic Correlations

The estimation of the genetic correlations between traits by the reciprocal correlation of one trait in the dam with another trait in the offspring is complicated where maternal environment has a direct influence. The formula given by Hazel (1943) was

$$r_{G_iG_j} = \sqrt{\frac{r_{X_iX_j'} \; r_{X_i'X_j}}{r_{X_iX_i'} \; r_{X_jX_j'}}},$$

where X_i, X_j are two different traits in the offspring and X_i', X_j' are the corresponding traits in the dam. This formula is valid for the conditions shown by Hazel, but, for traits influenced by maternal environment, the expectation of the formula given above is not $r_{G_iG_j}$. For

example, in the case of weaning gain and weaning score, from the correlation between offspring and dam,

$$r_{P_3P_5'} = \frac{g_3g_5\ r_{G_3G_5}}{2} + m_3g_4g_5\ r_{G_4G_5} + \frac{m_5g_4g_5\ r_{G_4G_5}}{4} + \frac{m_3m_5g_4}{2}.$$

The reciprocal correlation is

$$r_{P_3'P_5} = \frac{g_3g_5\ r_{G_3G_5}}{2} + m_5g_3g_4\ r_{G_3G_4} + \frac{m_3g_4g_5\ r_{G_4G_5}}{4} + \frac{m_3m_5g_4^2}{2}.$$

The correlation between the weaning gain of offspring and dam is

$$r_{P_3P_3'} = \frac{g_3^2}{2} + \frac{m_3^2g_4^2}{2} + m_3g_3g_4\ r_{G_3G_4} + \frac{m_3g_3g_4\ r_{G_3G_4}}{4} \text{ and}$$

$$r_{P_5P_5'} = \frac{g_5^2}{2} + \frac{m_5g_4^2}{2} + m_5g_4g_5\ r_{G_4G_5} + \frac{m_5g_4g_5\ r_{G_4G_5}}{4}.$$

For the conditions postulated by Hazel

$$r_{P_3P_5'} = r_{P_3'P_5} = \frac{g_3g_5\ r_{G_3G_5}}{2},\ r_{P_3P_3'} = \frac{g_3^2}{2}, \text{ and } r_{P_5P_5'} = \frac{g_5^2}{2}.$$

These conditions are not met in these data and valid estimates of genetic correlations could only be obtained from the paternal half-sib analysis.

Heritability Estimates

Heritability is defined as the fraction of the phenotypic variance determined by additively genetic differences. Stated another way it is the regression of genic value on phenotypic value. For traits that are influenced by genetic differences in maternal environment a clarification of genic value affecting the trait is needed. The total genic value affecting a trait is the genic value for direct response in that trait plus the genic value of maternal environment as it affects the trait. Let G_i be the calf's genic value for direct response of the i^{th} trait and G_j the calf's genic value for maternal environment affecting the i^{th} trait. The regression of $(G_i + G_j)$ on P_i is $r_{G_iP_i}\frac{\sqrt{G_i}}{\sqrt{P_i}} + r_{G_jP_i}\frac{\sqrt{G_j}}{\sqrt{P_i}}$. If epistasis is negligible the genetic relationships are as follows. The paternal half-sib correlation estimates .25 g_i^2. The regression of offspring on dam estimates .5 g_i^2 + .5 $g_j^2m_i^2$ + 1.25 $g_ig_jm_i\ r_{G_iG_j}$, provided the environmental factors affecting the P_i of the dam are not correlated with the environmental factors affecting her maternal environment. The regression of offspring on sire estimates, .5 g_i^2 + .25 $g_ig_jm_i\ r_{G_iG_j}$. The regression of $(G_i + G_j)$ on P_i for birth weight, weaning weight, weaning gain, and weaning score is g_i^2 + .5 $g_i^2m_j^2$ + 1.5 $g_ig_jm_i\ r_{G_iG_j}$. In this study this is most nearly approximated by adding the regression of offspring on sire and the regression of offspring on dam. The regression of $(G_i + G_j)$ on

P_i in the case of yearling gain and yearling score differs because of the negative direct influence of maternal environment of the dam on the phenotype of the calf. For these traits the regression of $(G_i + G_j)$ on P_i is $g_i^2 - .5\ g_j^2 m_i^2 - .5\ g_i g_j m_i\ r_{a_i a_j}$. The regression of $(G_i + G_j)$ on P_i in the case of yearling weight and yearling score cannot be obtained directly from the heritability estimates available. However, by referring to table 6 for various probable values of m_i^2, g_j^2, and $r_{a_i a_j}$ and using the paternal sib correlations for the estimate of g_i^2, a range of values thought to include the true heritability can be calculated. In the range of $m_i^2 = .49$ to $m_i^2 = .09$, and $g_j^2 = .25$ to $g_j^2 = .36$ the regression of $(a_i + a_j)$ on P_i for yearling gain was .39 to .42, and for yearling score was .26 to .29.

The heritabilities for the various traits taking maternal environment into account as outlined above are given in table 7.

TABLE 7. HERITABILITY ESTIMATES OF TOTAL GENIC VALUE, $G_i + G_j$ [a]

Birth weight	Weaning weight	Weaning gain	Weaning score	Yearling gain	Yearling score
.42	.19	.12	.16	.40	.27

[a] Where G_i is the genic value for direct response in the calf and G_j is the genic value for maternal environment in the calf.

These values represent most nearly the heritable differences for the traits as determined from these data.

Summary

The theoretical composition of paternal and maternal half-sib correlations, the correlations between offspring and dam, and offspring and sire were compared with observed values to estimate the influence of maternal environment. These comparisons suggest that maternal environment from conception to birth and from birth to weaning had a large influence on birth weight, gain from birth to weaning, and weaning score, but a small influence on yearling gain and yearling score. The results further suggest a negative correlation exists between maternal environment from birth to weaning and the traits weaning gain and score.

The consequences of selecting for various traits were examined particularly as to the effect on maternal environment. Selecting for weaning gain will increase genic value for growth response and to a slight

extent increase genic value for maternal environment. Part of the gain made will be nullified by the negative genetic correlation between maternal environment and growth response. Where calves are raised by nurse cows selecting for weaning gain will increase growth response but, because of negative genetic correlation, will result in a loss of genic value for maternal environment. Selecting cows which produce heavy calves would place greater emphasis on milking ability than on growth response so far as the genic value of the cows is concerned. Similar results are expected for weaning score.

Selecting on the basis of gain from weaning to yearling age will increase the genic value for yearling gain but will cause a small loss in genic value for milking ability.

Heritability estimates taking maternal environment into account were: birth weight, .42; weaning weight, .19; weaning gain, .12; weaning score, .16; yearling gain, .40; yearling score, .27.

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EFFECTS OF CHLORTETRACYCLINE FEEDING ON BOVINE RUMEN MICROORGANISMS [1]

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INCLUSION of antibiotics at low levels in ruminant feeds may increase the efficiency in food utilization (Bridges *et al.*, 1953; Jordan and Bell, 1954) and permit weight gains (Hatfield *et al.*, 1954; Kesler, 1954; Perry *et al.*, 1954) larger than those in control animals without antibiotics. It is usually assumed that the antibiotics change the composition of the rumen biota, but little experimental evidence has been obtained. A recently developed manometric method for measuring microbial activity in the rumen (Hungate *et al.*, 1955) has been applied to the problem of determining whether the low levels of antibiotic in the feed actually change the composition of the rumen flora.

Materials and Methods

Six steers used in the experiments were fed a ration with the following percentage composition on an air-dry weight basis: alfalfa hay, 82; fat, 7; barley, 5.25; milo, 1.75; oats, 1; beet pulp, 2; and salt 1. Three of the animals also received 5 mg. of chlortetracycline (Aureomycin) per pound of feed. This level was estimated to give a concentration in the rumen of about 1.4 mcg. per gm. of contents.

Rumen contents were removed by stomach tube and immediately transported to the laboratory. Eighty gm. were mixed with 5 gm. of finely ground alfalfa hay to provide a plentiful substrate for microbial activity. Ten gm. of this mixture was placed in the Warburg vessel. Thirty ml. of balanced salt solution was added in order to dilute the fermentation products and maintain a suitable acidity during the experiment. The salt solution had the following percentage composition: $NaHCO_3$, 0.5; NaCl, 0.1; $(NH_4)_2SO_4$, 0.05; KH_2PO_4, 0.05; K_2HPO_4, 0.05; $MgSO_4$, 0.01; and $CaCl_2$, 0.01; in tapwater.

The flasks were attached to the manometers, placed in the water bath at 39.1C and air in the flasks displaced with carbon dioxide. Manometric

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readings were started within 90 minutes after the rumen contents were collected. After readings showed that the fermentation rates in replicate vessels were similar, chlortetracycline (Aureomycin [4]) solution or water, respectively, was added from the sidearm. Pressure changes were followed, and after 75–110 minutes the fermentation was stopped by adding sulfuric acid. The carbon dioxide in the vessels was absorbed and the residual methane determined according to the previously described method (Hungate *et al.*, 1955).

The corrected volume of methane was divided by the vessel constant for methane to obtain the pressure increase due to methane. This increase amounted to approximately one-fourth of the total. It was assumed that throughout the experiment this same fraction of the pressure increase was due to methane and, for convenience, a single vessel constant for the total products was calculated as follows: $\frac{3K_{CO_2} + K_{CH_4}}{4} = K\text{total products}$.

Results and Discussion

Preliminary experiments tested inhibition by levels of added chlortetracycline similar to the estimated level in the rumen contents of the chlortetracycline-fed animals. This concentration, when added to the contents in the manometric vessel, failed to inhibit the fermentation. Slightly higher levels were tested, using rumen contents from a steer on a fattening ration containing no antibiotics. With an added chlortetracycline level of 3 mcg. per ml. no inhibition was detected, but at 6 mcg. per ml. the inhibition was greater than the experimental error and at 12 mcg. per ml. an inhibition of 16 percent was noted.

The inhibition by 12 mcg. per ml. was then tested with rumen contents from chlortetracycline-fed and control steers. Each sample of rumen contents was tested in four flasks, two with one-half ml. of chlortetracycline solution in the sidearm and two with one-half ml. of water. Results are shown in table 1.

Inspection of table 1 shows a significantly greater inhibition of microbial activity in rumen contents from the control steers. The chlortetracycline in the feed of the experimental animals apparently had selected organisms with increased chlortetracycline resistance. On the assumption that various bacteria were differentially susceptible to the antibiotic it may be concluded that inclusion of chlortetracycline in the feed caused a change in the composition of the rumen microflora. This was further borne out by the observation that in each experiment the rumen

[4] The Aureomycin (88 percent purity) was donated by Lederle Laboratories, Inc., Pearl River, New York.

contents from the animal receiving chlortetracycline were slightly greener in color, less brown, than the contents from the control.

In figure 1 all the manometric data for experiment 1 are plotted. It can be seen that the *in vitro* inhibition by chlortetracycline was expressed immediately after its addition and was relatively constant throughout the experiment. The inhibition of fermentation in rumen contents of the control was consistently greater than in the contents from the chlortetracycline-fed steer.

TABLE 1. EFFECT OF CHLORTETRACYCLINE ON THE *IN VITRO* [a] FORMATION OF FERMENTATION PRODUCTS BY RUMEN CONTENTS FROM CHLORTETRACYCLINE-FED AND CONTROL STEERS

	Rumen contents from animals fed chlortetracycline				Rumen contents from animals without antibiotic			
	Chlortetracycline				Chlortetracycline			
	Not added	Added	Difference		Not added	Added	Difference	
	μmol	μmol	μmol	percent	μmol	μmol	μmol	percent
Experiment 1		Animal no. 1				Animal no. 2		
106 minutes								
sample a	1525	1170			1340	867		
" b	1529	1223			1397	902		
average	1527	1197	330	21.6	1369	885	484	35.4
Experiment 2		Animal no. 3				Animal no. 4		
110 minutes								
sample a	1530	1225			1510	1025		
" b	1492	1222			1560	1000		
average	1511	1224	287	19.0	1535	1013	522	34.0
Experiment 3		Animal no. 5				Animal no. 6		
75 minutes								
sample a	1097	945			1055	657		
" b	1074	940			....	670		
average	1086	943	143	13.2	1055	664	391	37.0
Average inhibition				17.9				35.5

[a] Manometric procedures: In vessels, 10 gm. of rumen contents plus hay, and 30 ml. salt solution. In sidearm, 0.5 ml. H_2O or 0.5 ml. H_2O containing 480 mcg. chlortetracycline (base). CO_2 atmosphere. Temp. 39.1 C. At end of experiment one ml. 5–normal H_2SO_4 introduced via stopcock on sidearm.

Since methane production was measured during these experiments the extent of its inhibition could be compared with the total inhibition of the fermentation. In table 2 are shown the ml. of methane produced in the various vessels of the three experiments. It is evident that part of the total inhibition can be accounted for by decreased methane production but this decrease (32–87 umols, table 2) is insufficient to account for all the decrease (143–522 umols, table 1) in the total fermentation

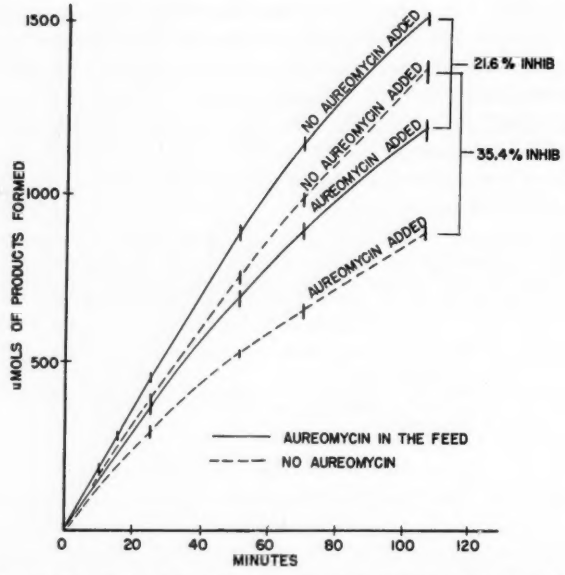

Figure 1. Formation of total fermentation products in experiment 1. (Each curve is the average from two flasks. The length of the upright bars indicates the differences between the duplicates.)

TABLE 2. AMOUNTS OF METHANE PRODUCED IN THE *IN VITRO* FERMENTATION BY RUMEN CONTENTS FROM CHLORTETRACYCLINE-FED AND CONTROL STEERS

	Rumen contents from animals fed chlortetracycline				Rumen contents from animals without antibiotic			
	Chlortetracycline				Chlortetracycline			
	Not added	Added	Difference		Not added	Added	Difference	
	µmol	µmol	µmol	percent	µmol	µmol	µmol	percent
Experiment 1								
sample a	397	308			388	308		
" b	393	...			384	299		
average	395	308	87	22.1	386	304	82	21.3
Experiment 2								
sample a	321	272			321	272		
" b	299	272			313	250		
average	310	272	38	12.9	317	261	56	16.9
Experiment 3								
sample a	353	317			272	227		
" b	331	303			...	227		
average	342	310	32	9.1	272	227	45	16.4

products. If the methane arises from intermediate products such as hydrogen and formate (Carroll and Hungate, 1955), it is highly probable that the observed decrease in methane production results not from a direct inhibition of the methanogenic bacteria, but from a diminution in the intermediate products from which the methane is formed. The organisms forming hydrogen and formate may be inhibited and the methanogenic bacteria receive less of these substrates.

Since the results of adding chlortetracycline to flask cultures indicated that the microbial population in the rumen had been changed, it was of interest to examine whether the ability of the rumen organisms to form fermentation products had been increased or diminished. The rates of production of total fermentation products during the first 25 minutes of the manometric experiments were calculated for the flasks in which no antibiotic was added. The short initial period of the experiments was selected in order to avoid the diminution in activity which occurred later due to exhaustion of substrate and accumulation of fermentation products. The results (each figure the average of two flasks) are shown in table 3.

TABLE 3. FERMENTATION RATES OF INGESTA FROM CHLORTETRACYCLINE-FED AND CONTROL ANIMALS

	Chlortetracycline-fed	No chlortetracycline
Experiment 1	17.7 μmol/min.	15.3 μmol/min.
" 2	15.2	16.9
" 3	18.7	16.0

The data in table 3 indicate that there was no great difference in the fermentative capacity of the rumen contents from the two groups of animals. Although small differences might be obscured by the variations between samples from animals on the same ration, the weight gains in the chlortetracycline-fed animals did not differ significantly from the controls, suggesting that the magnitude of the microbial fermentation was similar in the two groups.

Inhibition of rumen activity by streptomycin [5] was also tested in two experiments, using rumen contents from steers on a high grain ration without antibiotics. In the first experiment a streptomycin level of 20 ugm/ml did not give an inhibition greater than the experimental error, but in the second, a level of 50 mcg. per ml caused a 12 percent

[5] A. Merck and Co. preparation of streptomycin sulfate, oral veterinary, was used. The stated dosages give the amount of streptomycin base.

reduction in fermentation. This suggests that the rumen organisms are not inhibited as readily by streptomycin as by chlortetracycline.

Summary and Conclusions

Manometric experiments of short duration were employed to measure the total fermentation products of rumen contents from chlortetracycline-fed and control animals, both in the presence and absence of additional chlortetracycline. Inhibition by added antibiotic was greater in the control animals, indicating that chlortetracycline feeding had altered the composition of the rumen microbial population. Methane production was diminished by the added chlortetracycline but this was probably a secondary result from inhibition in the production of the intermediates, hydrogen and formate. The potential for microbial activity in the rumen contents from chlortetracycline-fed steers was about the same as in the controls.

The rumen micro-organisms appear to be somewhat more sensitive to chlortetracycline than to streptomycin.

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FACTORS ASSOCIATED WITH THE INTERVAL FROM PARTURITION TO FIRST ESTRUS IN BEEF CATTLE [1]

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IT is necessary to know the approximate interval from parturition to first estrus and some of the variables controlling this interval in order to regulate the breeding season and manage the herd for the maximum fertility and production. The object of this report is to indicate the association of several variables such as line, breed, age of cow, sex of calf, cow repeatability, and date of calving upon interval to the postpartum estrus. Also, a study was made of the fertility of cows when bred at different intervals following calving.

A study of the records of 43 beef cows by Guilbert and McDonald (1933) showed that 30 percent came into estrus between 20–40 days postpartum, 30 percent came into estrus between 40–60 days, and 40 percent between 60–100 days. They found no seasonal influence on this interval. Lasley and Bogart (1943) reported an average interval of 80.2 days to the postpartum estrus in Hereford range cows while Warnick (1953) found an interval of 50.6 days in Angus and 58.2 days in Hereford cows on irrigated pastures. In dairy cattle the average interval to the first postpartum estrus varies from 32.1 (Olds and Seath, 1953) to 71.8 days for nurse cows (Clapp, 1937). Heritability and repeatability of this interval has been studied by Chapman and Casida (1937) and Olds and Seath (1953). Since beef cattle are usually restricted to a limited breeding season the importance of information on the factors associated with the postpartum interval is apparent.

Materials and Methods

Observations were made for the occurrence of estrus following parturition on all the purebred Aberdeen-Angus and Hereford cows in the Oregon central station herd in 1951, 1952, and 1953. The cows were checked for estrus at approximately twelve hour intervals daily at 6:00 a.m. and 6:00 p.m. except in 1953 when they were checked at 7:00 a.m. and 5:00 p.m. each day. A cow was recorded in heat when she stood for

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the mounting and riding of other cows. The calving season extended from March 19 to July 1 in 1951, from March 24 to June 26 in 1952, and from March 6 to July 10 in 1953. The breeding season was limited to a three month season from June 20 to September 20, 1951, from June 1 to September 1, 1952, and June 3 to September 6, 1953. All cows were bred at the first estrus following the beginning of the breeding season irrespective of the interval from calving. Hand mating was practiced routinely except for a few instances of artificial insemination.

The cows were fed grass silage and a mixture of grass and alfalfa hay during the winter feeding period. During the grazing season, cows were

TABLE 1. THE AVERAGE INTERVAL TO FIRST POSTPARTUM ESTRUS IN BEEF COWS

Breed and line	1951		1952		1953	
	Number of cows	Average interval	Number of cows	Average interval	Number of cows	Average interval
		days		days		days
Hereford	23	52.4[a]	35	62.8	39	68.6
David Domino	8	52.9	9	67.1	13	82.6
Lionheart	6	60.5	13	64.0	10	67.8
Prince	7	52.3	10	56.1	16	57.8
Miscellaneous	2	26.5	3	67.0	..	...
Aberdeen-Angus	17	46.9	20	54.4	17	77.1

[a] Standard deviations for 1951, 1952, 1953 were 19.2, 23, 30.5, and for Angus and Hereford, 23 and 29.3, respectively.

either on irrigated Ladino clover-grass pastures or nonirrigated grass pasture. Iodized salt, bone meal and fresh water were available free choice throughout the year. The cows were provided adequate feed at all times and were in good physical condition during the three year period.

The data were handled by methods of analysis of variance, regression and correlation suggested by Snedecor (1946).

Results and Discussion

Postpartum Interval in Relation to Line of Hereford and Sex of Calf

There was wide variation in the interval from parturition to the postpartum estrus during the three years and differences among the various lines of Hereford cows (table 1) were not statistically significant. The average interval to the postpartum estrus in cows that gave birth to bull

TABLE 2. VARIANCE ANALYSIS OF INTERVAL TO POSTPARTUM ESTRUS

Source of variation	d/f	Mean square
Year	2	5,178.2**
Breed	1	318.1
Year x breed	2	972.4
Error	145	634.9

** P equal or less than 0.01.

calves was 61.5 days and 61.0 days for cows with heifer calves. Thus, sex of calf appeared to have no effect on interval to first estrus in this study.

Postpartum Interval in Relation to Breed and Year

Since there was no apparent effect of line of Hereford upon this interval all lines were combined in estimating breed and year effects (table 2). The average interval was 59.2 days in Angus cows and 62.7 days in Hereford cows. The difference was not statistically significant.

There was a highly significant difference in interval due to years (table 2). The average interval including all cows was 50.2 days in 1951, 59.8 days in 1952 and 71.2 days in 1953. The explanation for these differences is not apparent. Management, feeding and treatment of the cows were comparable for the three years, except cows were checked one hour later in the morning and one hour earlier in the evening in 1953 than during the other two years.

Postpartum Interval in Relation to Age of Cow

The average interval to first estrus following calving among the various age groups (table 3) varied from 55.0 days in 6 year old cows

TABLE 3. EFFECT OF AGE OF COW AT CALVING UPON INTERVAL TO FIRST POSTPARTUM ESTRUS

Age of cow	Number	Average interval to postpartum estrus
		days
2	30	57.2
3	41	57.7
4	25	64.7
5	11	76.5
6	10	55.0
7	10	57.7
8–15	24	67.1
Total	151	61.4

to 76.5 days in 5 year old cows. There was no apparent trend associated with age and mean differences were not significant.

Postpartum Interval in Relation to Date of Calving

The average interval to the postpartum estrus for cows which calved during the first half of the season was 28.3 days longer for Hereford and 25.5 days longer for Angus than for those that calved during the last half. Covariance analysis showed a significant negative relationship between date of calving and interval from calving to the postpartum estrus. There was a negative regression of — 0.51 for Angus and — 0.64 in Hereford cows (table 4). The highly significant negative correlation of the date of calving and interval to first estrus of — 0.56 in Angus

TABLE 4. THE RELATIONSHIP OF INTERVAL TO FIRST ESTRUS TO DATE OF CALVING

Breed	d.f.	b	r
Aberdeen-Angus	53	—0.51**	—0.56**
Hereford	94	—0.64**	—0.64**
Total	147	—0.61**	—0.62**

** P equal or less than 0.01.

and — 0.64 in Hereford cows indicates that 31 and 41 percent of the variation for the respective breeds in this interval could be eliminated by knowing the calving dates.

Repeatability of Postpartum Interval

There were three postpartum intervals available on 27 cows and two intervals on 23 cows which were used to estimate repeatability of interval for the same cow during different years. Analysis of variance showed cow effects to be insignificant. The intra-class correlation of intervals for the same cow were used as estimates of repeatabilities. The estimates were — 0.04 in cows with three observations and 0.14 in cows with two observations. A combined estimate of repeatability of 0.06 was obtained by combining the two groups and computing variance components after adjustment for the numbers of observations within cows.

Fertility in Relation to Postpartum Interval to Breeding and Estrus

The cows were grouped into 20-day intervals based on the time of breeding following parturition and the estrus at which bred, then the percentage of cows calving after the first breeding was determined (table 5). The average fertility varied from 11.1 percent in the 11–30 day group to 100 percent for the 131–170 day group. These differences in fertility among the various groups were not statistically significant

when tested by the Chi-Square method, but it should be noted that numbers were small in several groups. The average fertility following first service for all cows irrespective of interval was 74 percent.

The estrous period following calving at which breeding occurred was known and fertility was determined for cows bred at the first and second (includes 7 cows bred at third) periods. Combining the Angus and Hereford cows, the percentage of cows calving when bred at the first estrus

TABLE 5. FERTILITY IN BEEF COWS BRED AT VARIOUS INTERVALS FROM PARTURITION AT DIFFERENT ESTROUS PERIODS [a]

Interval to First breeding	First estrus		Second estrus [b]		Total	
	No. bred	% Calved	No. bred	% Calved	No. bred	% Calved
days						
11– 30	8	12.5	1	0.0	9	11.1
31– 50	24	58.3	2	50.0	26	57.7
51– 70	29	82.8	11	63.6	40	77.5
71– 90	22	81.8	14	78.6	36	80.6
91–110	9	88.9	9	100.0	18	94.4
111–130	6	83.3	5	80.0	11	81.8
131–170	2	100.0	4	100.0	6	100.0
Total	100	72.0	46	78.3	146	74.0

[a] All percentages are based on first exposure breeding and not return to a second service.
[b] Includes 6 of 7 (85.7 percent) cows which calved to breeding at third estrus.

was 72 and 78.3 percent at the second estrus (table 5). It should be emphasized that cows were bred at the first estrus following the beginning of the breeding season, and the estrus at which breeding occurred was determined automatically by date of calving and length of interval to first estrus. The difference in fertility between the two periods was not statistically significant.

Discussion

The average postpartum interval to estrus of 62.7 days for the Hereford cows in these data was considerably shorter than the 80.2 days for Hereford range cows reported by Lasley and Bogart (1943). This difference could be due to nutritional, management or climatic factors or the interaction of these factors. It is interesting that the variations in the Missouri and Oregon data were similar, as is shown by their respective coefficients of variation, 43.1 vs. 45.0 percent. The postpartum interval of 59.2 days for the Angus cows in this study was longer than the 47.2 days in 24 Angus cows reported under Wisconsin conditions by Hauser (1954). The average interval to the first estrus in the present

study was intermediate among the various intervals reported for dairy cows, approaching the 69.3 days reported by Chapman and Casida (1937).

The significant year effect upon the postpartum interval was due to unknown factors since herd management was similar, and level of nutrition was adequate based on condition of cows during all three years. There is the possibility that the one hour delay in checking time in the morning and checking one hour earlier in the evening may have caused some of the short estrous periods to go unnoticed, resulting in an apparent longer interval during 1953. It is possible that various uncontrolled environmental factors such as length of day or temperature, acting singly or interacting with genetic factors could account for the differences.

There was little difference in the average interval to first postpartum estrus among the 2, 3, 6 and 7 year old cows, the means varying from 55.0 to 57.7 days. The interval among the 4, 5, and 8–15 year old cows was slightly longer, varying from 64.7 to 76.5 days. However, this difference was not statistically significant. Herman and Edmondson (1950) showed that in dairy cows less than 3 years old and cows 13 to 14 years, the postpartum interval was 15 to 25 days longer than in cows 3 to 10 years old.

The significant influence of the date of calving upon interval to first estrus was apparent within years and within breeds. No seasonal effect of calving on the postpartum estrual interval was observed in beef cows by Guilbert and McDonald (1933), or in dairy cows by Herman and Edmondson (1950). Chapman and Casida (1937) found longer postpartum intervals in the spring (March–April, May–June) compared to other seasons in the more typical cows. However, Hammond and Sanders (1923) observed shorter service intervals in the spring compared to the winter season in dairy Shorthorns. The latter authors suggested a seasonal difference in length of estrus which would cause some estrous periods to go undetected during the winter season. It is possible that differences in length of day could be acting on the pituitary gland to produce an earlier and higher gonadotrophin secretion to bring about estrus in those cows which calved later in the season. There is also the possibility that the gonadotrophin level was sufficient to bring about ovulation but not estrus in the early-calving cows since Casida and Wisnicky (1950) found that approximately 68 percent of the dairy cows ovulate before showing the postpartum estrus. However, in this study time of first ovulation was not determined. A seasonal influence upon reproductive performance has been demonstrated in sheep by

several authors and in swine on age at puberty by Wiggins *et al.* (1950). Also, it is possible that other environmental factors such as quality or quantity of feed supply, temperature changes and interaction of these factors could be responsible for the seasonal differences found in these data. It is possible that seasonal effects on reproductive performance could be expected in beef cattle since they have been selected for seasonal production.

The low repeatability of 0.06 for the postpartum interval is in agreement with the work of Brown *et al.* (1954) where they found practically a zero repeatability in the calving interval. However, these data differ with the work in dairy cattle by Chapman and Casida (1937) and by Olds and Seath (1953) who showed a 19 and 27 percent repeatability, respectively, in the postpartum estrual interval. The significant effect of the date of calving and year influence on the interval in this study could possibly mask a certain amount of the cow variability, therefore, giving a lower repeatability.

The effect of interval to first breeding on fertility is in general agreement with the results of Lasley and Bogart (1943) where fertility was lowest during the 10–40 day interval in beef cows. In dairy cows Shannon *et al.* (1952) showed a significant difference in fertility with a gradual increase as the postpartum interval increased. The overall fertility at first service was 50.9 compared to 74 percent in the beef cows in this study.

The small nonsignificant differences in fertility observed when cows were bred at the first (72 percent) or second (78.3 percent) estrus would indicate that the estrus at which breeding occurred did not influence fertility. These data would seem to indicate that there is greater variation in fertility at the various intervals following breeding than the particular estrus at which bred. There is the possibility that the short postpartum estrual intervals were accompanied by an anovulatory estrus which would be infertile similar to the condition in some low fertility beef cows (Burns *et al.*, 1954).

Summary

The average interval from parturition to the first estrus was 59.2 days in 54 Angus cows and 62.7 days in 97 Hereford cows during a 3-year period. The line of breeding within the Hereford cows and breed difference between the Angus and Hereford cows had no significant effect on the postpartum estrual interval. There was a highly significant effect of year on this interval. The age of cow at calving and sex of calf did not appear to influence the postpartum estrual interval.

The cow repeatability of this postpartum estrual interval was 0.06. There was a highly significant regression of — 0.61 of the date of calving upon the interval from calving to the postpartum estrus. Therefore, a cow tended to have a shorter interval of 6.1 days for each 10 days that she calved later in the season. This phenomenon should contribute to a more uniform calving interval from one year to the next.

There was no significant effect of the interval from calving to breeding on fertility, although there was a gradual increase in fertility from the 11–30 day group to the 91–110 day group. The overall fertility following the first service was 74 percent. The fertility of cows bred for the first time at the first and second estrus irrespective of interval length was 72 and 78.3 percent, respectively.

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THE EFFECT OF DIFFERENT LEVELS OF DIETARY OXYTETRACYCLINE ON THE GROWTH OF YOUNG DAIRY CALVES [1]

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THE value of certain antibiotics in increasing growth and controlling disease in young calves has been well established. Although most of the work reported has been with chlortetracycline (Aureomycin) Kessler (1954) and Voelker and Jacobson (1953) have shown that oxytetracycline (Terramycin) will also exert these beneficial effects. In a previous trial at the Vermont Experiment Station MacKay *et al.* (1953) obtained a significant growth increase when terramycin was fed to calves at the rate of 30 mg. per 100 lb. of body weight. This increase was comparable to that obtained with oxytetracycline (MacKay *et al.* 1952).

In an effort to determine the optimum level of feeding oxytetracycline, this investigation was undertaken to study the effects of high and low levels of oxytetracycline feeding on the growth of young calves.

Experiment

Twenty-seven heifer calves were divided into 3 groups and placed on trial as they were dropped in the Station herd. Each group contained 5 Holsteins, 2 Ayrshires, 1 Jersey and 1 Guernsey. Group 1 served as the control, Group II was fed 15 mg. of oxytetracycline per 100 lb. of body weight daily, while Group III received 60 mg. of oxytetracycline. Weekly adjustments in feeding were made for gains in body weight. The oxytetracycline was fed in the milk as a powdered feed supplement containing 5 gm. of crystalline oxytetracycline per pound of supplement.

The calves were fed whole milk for the first month and then skim-milk until 3 months of age. They were allowed free access to good quality grass hay and were fed a 20 percent protein concentrate up to a maximum of 4 lb. daily. The calves were on experiment until 12 weeks

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of age, and were housed in the regular calf barn, where, for 2 years prior to this trial, most calves had an antibiotic in their ration.

During the course of the trial, blood samples were drawn from 6 supplemented calves and 6 controls of similar age. Hemoglobin measurements and white blood cell differential counts were made on these samples to determine possible modes of action of oxytetracycline in stimulating growth.

Results and Discussion

The averge daily gain in body weight for the 3 groups during the first, second, and third 4-week periods is shown in table 1. Statistically,

TABLE 1. THE EFFECT OF TERRAMYCIN ON THE WEIGHT GAINS OF DAIRY CALVES FROM BIRTH TO 12 WEEKS OF AGE

	Average initial weight	Average daily gain in weight			Average final weight
		0–4 weeks	4–8 weeks	8–12 weeks	
	lb.	lb.	lb.	lb.	lb.
Group I (Control)	83.6	0.91	1.78	1.74	208.2
Group II (Supplemented 15 mg./100 lb.)	84.0	1.18	1.76	1.70	214.0
Group III (Supplemented 60 mg./100 lb.)	85.1	1.15	1.78	1.66	213.7

these gains did not differ significantly at any time (Snedecor, 1946). Therefore, neither level of oxytetracycline improved the growth rate of the calves.

Further study revealed that this lack of response to oxytetracycline feeding was not due to slower growth of the supplemented calves but to more rapid growth of the controls. This was further emphasized when the results of this experiment were compared with those of two previous experiments (MacKay *et al.*, 1952, 1953) which had been conducted in the same barn under identical feeding and management conditions.

Due to the different numbers of calves of each breed in these trials, the pounds of gain over the Ragsdale Standard (1934) at 3 months of age were used as the criterion of response. In the trial conducted in 1952 the calves fed aureomycin at the 30 mg. level averaged 38.1 lb. above the Ragsdale standard as compared to 21.0 lb. for the controls.

In 1953 the oxytetracycline-fed (30 mg. level) calves averaged 40.9 lb. while the controls averaged 25.9 lb. above the standard. In the current trial, the group receiving 15 mg. oxytetracycline averaged 43.5 lb., the group fed 60 mg. averaged 43.1 lb., while the controls averaged 37.7 lb. over the Ragsdale standard. This increased growth in the controls as compared with previous years, probably accounts for the reduced difference between the controls and the antibiotic. However, the calves fed the supplement still had a slightly higher final weight than was evident in previous years.

These results may be explained by the reduction or elimination of antibiotic-susceptible pathogenic organisms especially those which cause "scours" which had been present in the calf-herd environment. In other words, the calves used in this latest trial were healthier than the calves used in the two previous experiments even though all appeared healthy.

It appeared possible that the mode of action of oxytetracycline in stimulating growth might be due to increased red blood cell and/or hemoglobin formation, or the oxytetracycline might be destroying low-grade pathogenic bacteria in the intestinal tract which cause minor infections and interfere with digestion and absorption of nutrients. If the latter was the case, the controls might have a higher percentage of neutrophiles which would be a reflection of an infectious disease process. However, no difference was found in either the hemoglobin levels or the white blood cell differentials and both were within normal ranges for the species. Hence, there was no evidence of a low-grade infection in the controls that was being suppressed in the treated calves.

Summary

Feeding a supplement containing oxytetracycline to dairy calves at the rate of 15 mg. or 60 mg. per 100 lb. of body weight did not result in a significant difference in rate of gain between the two levels of feeding. Furthermore, the antibiotic produced only a slight though insignificant increase in gain over the controls under the conditions of this experiment. This lack of growth response was probably due to a reduction or elimination of certain low-grade pathogens in the Station calf herd as a result of the continuous feeding of antibiotics to most calves during the previous two years.

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THE INFLUENCE OF ORAL ADMINISTRATION OF DIETHYLSTILBESTROL TO BEEF CATTLE

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PRELIMINARY experiments (Burroughs *et al.*, 1954) demonstrated the effectiveness of oral administration of diethylstilbestrol (stilbestrol) in increasing liveweight gains in fattening cattle and reducing feed requirements per unit of liveweight gain. No undesirable effects such as mounting, high tailheads, mammary development, or inferior beef carcasses were noted in these experiments similar to undesirable effects noted by pellet implantation of stilbestrol (Sykes *et al.*, 1953).

The purpose of this paper is to present additional experiments demonstrating the effectiveness of oral administration of stilbestrol upon liveweight gains, feed requirements, and feedlot behavior of cattle receiving different types of rations. Studies dealing with beef carcass evaluations and tissue residue data will be presented in subsequent papers.

Experimental Procedure

Five feeding experiments were conducted with either yearling steers or heifers using high-grain fattening rations, high-roughage growing rations or rations intermediate in grain and roughage content. In each experiment the only ration variable in respective cattle lots was the absence or presence of different levels of stilbestrol incorporated in the feed.

Experiment 1

Four lots of 8 animals each of good to choice feeder-grade yearling Hereford steers weighing approximately 700 lb. initially were group fed a heavy corn fattening ration for 112 days (Oct. 23, 1953 to Feb. 12, 1954). The steers were randomly allotted by outcome groups based primarily on initial weight. The approximate average daily ration per steer

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TABLE 1. AVERAGE DAILY FEED CONSUMPTION PER ANIMAL OF STILBESTROL-FED CATTLE

Lot No.	Stilbestrol	Ground Corn		Silage		Hay	Supplement		Min. Mix	Salt
		Shelled	Ear	Grass	Stover		SBOM	Mixed		
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
					Experiment 1					
1	None	12.7	....	....	11.8	2.5	2.0	....	.04	.01
2	2.75	12.7	....	....	11.9	2.5	2.0	....	.03	.01
3	5.5	14.6	....	....	11.8	2.5	2.0	....	.06	.01
4	11.0	14.6	....	....	11.7	2.5	2.0	....	.05	.01
					Experiment 2					
1	None	12.6	....	....	3.5	4.3	2.0	....	.02	.01
2	5.0	12.8	....	....	3.5	4.2	2.0	....	.02	.04
3	10.0	12.6	....	....	3.5	4.3	2.0	....	.02	.01
4	20.0	13.7	....	....	3.5	4.3	2.0	....	.02	.02
					Experiment 3					
1	None	....	17.3 [a]	....	....	....	....	2.9	.02	.01
2	6.0	....	16.9 [a]	....	....	....	....	2.9	.02	.01
3	12.0	....	17.7 [a]	....	....	....	....	2.9	.02	.01
					Experiment 4					
1	None	....	2.4	48.8	....	....	....	1.0	.12	.06
2	5.0	....	2.7	48.7	....	....	....	1.0	.14	.06
3	None	....	2.5	....	25.4	5.2	1.1	1.0	.14	.05
4	5.0	....	1.4	....	26.0	5.2	1.1	1.0	.13	.03
					Experiment 5					
1	None	6.8	....	....	16.6	4.3 [b]	....	3.7	.05	.02
2	10.0	7.1	....	....	17.6	4.3 [b]	....	3.7	.05	.04

[a] Mixture of 60% rolled corn and 40% ground corncobs.
[b] Mixture of hay and ground corncobs.

in the various lots (table 1) consisted of 13 to 14 lb. of cracked shelled corn, 12 lb. of corn stover silage, 2.5 lb. of alfalfa hay, 2 lb. of soybean oil meal, and free access to salt and a mineral mixture. The mineral mixture consisted of 40 percent bone meal, 37 feeding limestone, 20 iodized salt and 3 percent of a trace mineral premix containing ferrous sulfate 35 percent, copper sulfate 27 percent, zinc sulfate 1 percent, and manganese sulfate 24 percent. Diethylstilbestrol was incorporated into the daily allowance of soybean oil meal such that stilbestrol was supplied at the level of none in lot 1, 2.75 mg. in lot 2, 5.5 mg. in lot 3 and 11.0 mg. in lot 4 per steer daily. Daily observations of the cattle were made with respect to mammary development, restlessness or riding in the feedlot, and any unusual body conformation characteristics of the cattle. The cattle were weighed individually on 3 consecutive days at the beginning and at the end of the feeding period and at 28-day intervals throughout the progress of the experiment. Immediately following the close of the feeding period, the animals were slaughtered for carcass measurements and tissue samples.

Experiment 2

In the second experiment 4 lots of 8 animals each of yearling Hereford steers were group fed for 120 days (March 3 to July 1, 1954) a heavy corn fattening ration similar to the ration fed in experiment 1. These cattle were purchased as good to choice grade feeders weighing approximately 825 lb. at the beginning of the feeding period. The approximate average daily ration consumed per animal (table 1) was 13 lb. of ground shelled corn, 3.5 lb. of corn stover silage, 4 lb. of alfalfa hay, 2 lb. of soybean oil meal, and free access to salt and a mineral mixture similar to that used in experiment 1. Stilbestrol was dissolved in corn oil and incorporated in the soybean oil meal such that it would supply average daily amounts of stilbestrol per animal as follows: none in lot 1, 5 mg. in lot 2, 10 mg. in lot 3, and 20 mg. in lot 4. Daily observations made in the feedlot, and other procedures were similar to those described in experiment 1.

Experiment 3

Three lots of 8 animals each of choice Hereford-Angus cross-bred yearling heifers were group-fed for 113 days (Jan. 13 to May 7, 1954) a heavy corn fattening ration. The heifers were all open except for one animal in lot 3. The ration consisted of a full feed of a mixture of rolled shelled corn 60 percent and ground corncobs 40 percent (table 1)

and a limited feed (2.9 lb. daily per heifer) of a supplement. The supplement contained the following: soybean oil meal 70 percent, dehydrated alfalfa meal 10, dried cane molasses 10, urea 4, bone meal with cobalt 4 and limestone 2. One ounce of cobalt sulfate (5 gm. cobalt) was mixed into 250 lb. of bone meal. Salt and a mineral mixture similar to that described in experiment 1 were fed free-choice. Stilbestrol was dissolved in corn oil and thoroughly mixed into the supplement such that each heifer received an average of 12 mg. of stilbestrol in lot 3, 6 mg. in lot 2, and no stilbestrol in lot 1. In addition to previously described observations the reproductive organs of the heifers were examined rectally by veterinarians at the beginning, midway in the feeding period, and at the end of the experiment for any characteristic which might be expected to be stimulated by estrogen administration.

Experiment 4

Four lots of 10 head each of good to choice grade yearling steers were fed high-roughage growing rations with only minimal amounts of concentrate feeds from December 18, 1953 to April 24, 1954. Roughage was fullfed in all lots. In 2 experimental lots the roughage consisted of good grade brome-alfalfa silage made without wilting and without a preservative. The roughage fed to the other 2 lots of cattle (table 1) consisted of a mixture of good grade brome-alfalfa hay and corn stover silage. The corn stover silage contained 50 lb. of cane molasses per ton as a preservative. The concentrates fed with the 2 brome-alfalfa silage rations were ground ear corn (about 2.5 lb. daily per animal) and 1 lb. of a supplement per steer daily. The supplement consisted of: ground corncobs 47 percent, cane molasses 30, torula yeast 15, bone meal with cobalt (one ounce of cobalt sulfate plus 250 lb. of bone meal) 7.5, and a vitamin B_{12} preparation (Merck's) containing 20 mg. of vitamin B_{12} per lb. One of the brome-alfalfa silage lots of cattle received 5 mg. per animal daily of stilbestrol mixed in the supplement whereas the other lot received no stilbestrol. The two lots of cattle receiving the corn stover silage and hay rations, one with and one without 5 mg. of stilbestrol per head daily, received similar concentrate feeds to those described above except for the feeding of one additional pound of soybean oil meal per animal per day. The cattle were weighed on 3 consecutive days at the beginning and end of the experiment and at 28-day intervals throughout the feeding period.

TABLE 2. LIVEWEIGHT GAINS AND FEED REQUIREMENTS PER UNIT OF GAIN IN STILBESTROL-FED CATTLE

Lot No.	Stilbestrol	Days on feed	Initial body wt.	Final body wt.	Aver. daily gain [a]	Feed required per 100 lb. gain				
						Gr. corn	Roughage air dry basis	Supp. plus min.	Total air dry basis	Decrease
			lb.	lb.	lb.	lb.	lb.	lb.	lb.	%
					Experiment 1					
1	None	112	691	941	2.23	569	289	92	940	....
2	2.75	112	693	968	2.46	518	263	83	864	8.1
3	5.5	112	696	992	2.64	552	244	78	874	7.0
4	11.0	112	696	1039	3.06	479	210	67	756	19.5
					Experiment 2					
1	None	120	824	1107	2.36	533	231	86	850	....
2	5.0	120	823	1132	2.58	496	209	78	783	7.9
3	10.0	120	825	1123	2.48	508	218	81	807	5.1
4	20.0	120	825	1177	2.93	467	186	68	721	15.2
					Experiment 3					
1	None	113	642	873	2.03	511	341	146	998	....
2	6.0	113	643	896	2.23	455	303	130	888	11.0
3	12.0	113	643	909	2.34	455	303	124	882	11.6
					Experiment 4					
1	None	127	659	797	1.09	220	1495	108	1823	....
2	5.0	127	671	825	1.21	223	1338	100	1661	8.9
3	None	127	663	804	1.11	225	1234	206	1665	....
4	5.0	127	676	830	1.21	116	1146	187	1449	13.0
					Experiment 5					
1	None	243	662	1047	1.75	387	560	211	1158	....
2	10.0	243	621	1115	2.03	349	503	182	1034	10.7

[a] The standard errors of the mean average daily gains are 0.137, 0.148, 0.144, 0.089 and 0.061 in experiments 1, 2, 3, 4 and 5, respectively.

Experiment 5

Two lots of good grade feeder steers (8 animals per lot) weighing on the average 625 lb. were fed a high-roughage ration for 168 days followed by a high-grain ration for a 75-day finishing period (Oct. 28, 1953 to June 28, 1954). One lot of steers received no stilbestrol whereas the other lot received 10 mg. per animal daily throughout the entire feeding period. The approximate average daily ration fed per animal during the first 168 days was 25 lb. of corn stover silage, 2.5 lb. of ground corncobs, 4 lb. of ground ear corn, and 4 lb. of a supplement consisting of 42 percent soybean oil meal, 22 cane molasses, 22 dehydrated alfalfa meal, 5 urea, 5 torula yeast, and 4 bone meal. During the last 75-day feeding period the approximate daily ration per animal consisted of 14 lb. of ground shelled corn, 3.5 lb. of ground corncobs, 5 lb. of hay, and 2.5 lb. of the above supplement.

Results and Discussion

Liveweight gains were stimulated by the feeding of stilbestrol in each of the five experiments (table 2). In experiment 1 the greatest stimulation (2.23 lb. compared with 3.06 lb. daily gains) resulted from feeding 11 mg. of stilbestrol per animal daily. Less stilbestrol in the ration (2.75 and 5.5 mg. per animal) stimulated gains considerably but to a lesser extent than the 11 mg. level. Feed requirements per unit of gain were likewise reduced in each instance where stilbestrol was fed. The greatest reduction (19.5 percent) occurred where the 11 mg. level was fed, whereas 8.1 and 7.0 percent savings in feed requirements occurred at the 2.75 and 5.5 mg. levels, respectively. Feed consumption was stimulated 5 percent by stilbestrol feeding in this experiment. No undesirable effects from stilbestrol feeding were observed in the feed lot such as coital mimicry, mammary development, high tailheads, or relaxation of the muscles in the sacral lumbar region. Likewise no undesirable characteristics in the stilbestrol-fed cattle were noted at the end of the experiment by the cattle purchaser.

In experiment 2 where a high-corn fattening ration was fed similar to the ration fed in the first experiment, liveweight gains were again stimulated by each level of stilbestrol placed in the cattle feed. The stimulation at the 10-mg. level was not quite as great as that observed either at the 5 or 20-mg. feeding levels; however, it may be that disease (hoof rot) in this lot of cattle was responsible for their relatively poor showing. Feed requirements per unit of liveweight gain were reduced by the oral administration of stilbestrol in each lot of cattle, the greatest

reduction (15.2 percent) occurring at the highest level of stilbestrol feeding (table 2). No undesirable effects in the feedlot were noticed from stilbestrol feeding in this experiment. The packer buyers examining the cattle paid essentially the same price for each lot of cattle irrespective of treatment. For example, the prices paid per hundred weight in lots 1, 2, and 3 was $23.25 and in lot 4 the price paid was $23.00.

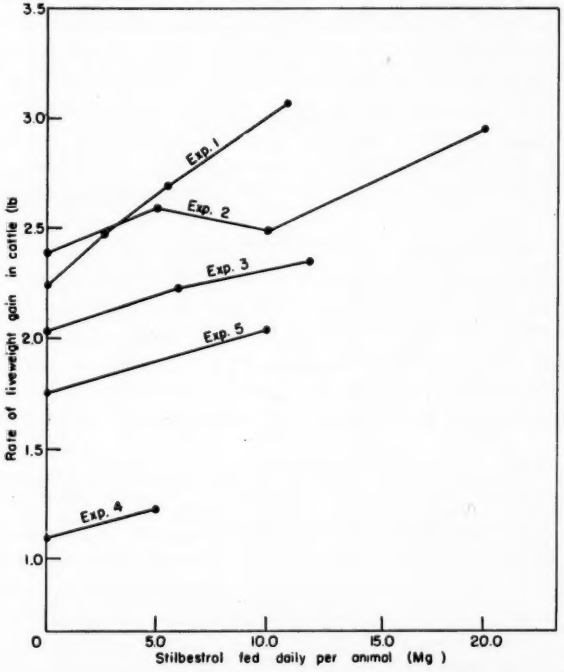

Figure 1. Influence of stilbestrol feeding upon cattle liveweight gain.

The heifers fed stilbestrol in the third experiment responded by making more rapid liveweight gains at reduced feed costs as compared with similar heifers receiving no stilbestrol. Rate of gain was stimulated as much as 0.31 lb. per heifer daily (table 2) which is not quite as much stimulation as that noted with steers in experiments 1 and 2. Feed requirements per unit of gain with stilbestrol feeding was reduced 11 to 12 percent with the heifers which compares favorably with 5 to 20 percent in the case of the steers fed somewhat comparable rations and comparable levels of stilbestrol in the 2 previous experiments. No unde-

sirable effects from stilbestrol feeding were observed in these heifers such as excessive riding, prolapse of the uterus, mammary development, etc. which has sometimes (Clegg *et al.*, 1953) accompanied the pellet

TABLE 3. LIVEWEIGHT GAINS BY 28-DAY PERIODS IN STILBESTROL-FED CATTLE

Lot No.	Stil-bestrol	Period 1	2	3	4	5	Total
	mg.	lb.	lb.	lb.	lb.	lb.	lb.
				Experiment 1			
1	None	69	74	68	39	....	250
2	2.75	72	92	64	47	....	275
3	5.5	82	95	87	32	....	296
4	11.0	76	109	89	56	....	330
				Experiment 2			
1	None	76	62	65	67	13 [a]	283
2	5.0	80	47	86	102	—5 [a]	310
3	10.0	74	61	70	89	4 [a]	298
4	20.0	97	73	74	94	14 [a]	352
				Experiment 3			
1	None	64	61	42	63	....	230
2	6.0	67	78	54	55	....	254
3	12.0	72	82	54	57	....	265
				Experiment 4			
1	None	43	2	56	19	18	138
2	5.0	31	3	63	21	36	154
3	None	17	30	49	27	17	140
4	5.0	35	35	42	37	6	155
				Experiment 5			
1	None	69	48	32	26	69	....
2	10.0	72	65	31	34	68	....
		Periods 6		7	8	9	
1 }	Continuation	} 43		47	72	19 [b]	425
2 }	of exp. 5	} 64		48	89	23 [b]	494

[a] 8-day period.
[b] 19-day period.

administration of stilbestrol in fattening heifers. Also the rectal examination of the heifers for follicles and corpora lutea revealed no demonstrable changes in the stilbestrol-fed heifers compared with the controls.

The steers receiving the high-roughage growing rations, experiment 4, responded to stilbestrol treatment almost as well as cattle receiving the

high-grain fattening rations. Liveweight gains were stimulated by approximately 10 percent. Feed savings per unit of gain amounted to 9 to 13 percent (table 2). Similarly a response from stilbestrol feeding was obtained in experiment 5 where a ration intermediate in roughage and concentrate feeds was fed over an 8-month period. Feed consumption was increased 6 percent in the stilbestrol-fed lot as compared with the control lot of cattle. Liveweight gains were stimulated by 15 percent with 11 percent feed savings in this final experiment which was conducted for twice as long a feeding period as the 4 previous experiments.

An analysis of variance was computed on the average daily gains in each of the experiments. Statistical significance at the 0.05 percent level was attained in experiments 1 and 5 and was approached in each of the other 3 experiments. The consistence of the response (figure 1) to stilbestrol in different experiments with different rations confirms the existence of a true effect.

Based upon all experiments, it appears that stilbestrol feeding is just as effective towards the end of the feeding period as it is during the early part of the feeding period. This is evident by an analysis of the 28-day gains made by the cattle in the various lots throughout the five experiments (table 3). The extra gains made by the stilbestrol-fed cattle over the control cattle during the last half of the respective experiments was fully as great as the comparable extra gains during the first half of the feeding trials.

It seems fair to conclude that in addition to the increased liveweight gains and lowered feed costs brought about by stilbestrol feeding, the absence of observable undesirable side effects in the feed lot from oral administration of stilbestrol in each of the five experiments suggests the desirability of feeding stilbestrol. Also the ease of oral administration of stilbestrol in the experiments resulted in minimal labor and effort since the experimental animals required no special restraining or handling. It is estimated that somewhat larger quantities of stilbestrol were required daily per animal by oral administration in these experiments as compared to what would have been required if pellet or parenteral administration of stilbestrol had been used. However, the additional amounts needed by this method of oral administration for growing and fattening beef cattle in bringing about desirable results is not as great as might have been expected (20 to 100 times) based upon estrogen experiments in lactating goats and dairy cows (Lewis and Turner 1942, and Mixner *et al.*, 1944). Finally it would appear that oral administration of stilbestrol offers a practical method whereby the most effective amount of

this estrogenic substance can be critically supplied to cattle from day to day for any desired period of time.

Summary

Five feeding experiments with yearling steers or heifers were conducted using high-grain fattening rations, high-roughage growing rations, or rations intermediate in grain and roughage content in studying the influence of oral administration of diethylstilbestrol upon liveweight gains and feed requirements per unit of liveweight gain. In each experiment and on each type of ration, liveweight gains were increased (averaging 20 percent) and feed requirements in producing a given gain were reduced (averaging 11 percent) by incorporating stilbestrol in the feed in effective amounts (averaging between 5 and 10 mg. of stilbestrol per animal per day). The presence of stilbestrol in the feed increased feed consumption of the cattle an average of about 5 percent. The response of oral administration of stilbestrol was equally as effective the last half of the feeding periods as the first half when all 5 experiments were considered. No observable undesirable side effects from stilbestrol feeding occurred in any of the experiments similar to those reported by other means of stilbestrol administration.

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THE BREEDING HISTORY OF AN EXPERIMENTAL HERD OF DWARF BEEF CATTLE [1, 2, 3]

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THIS paper presents the breeding history of an experimental herd of dwarf Herefords of the type described by Johnson *et al.* (1950). The form of hereditary dwarfism discussed herein was further described by Lindley (1951), Carroll *et al.* (1951), and Gregory *et al.* (1951, 1952, and 1953). That dwarfs exhibiting similar characteristics appear in the Aberdeen-Angus and Shorthorn breeds was indicated by Gregory *et al.* (1951). Gregory *et al.* (1953) believed that this dwarfism differs morphologically from the Aberdeen-Angus dwarfism reported by Baker *et al.* (1951). It also differs, in its phenotypic expression, from the "Stumpy" Shorthorn described by Baker *et al.* (1950).

This report is presented in answer to inquiries received by the authors from other workers interested in dwarf research. Although the material presented will describe a number of limitations imposed by the anomaly on afflicted animals, such animals do have potential value as research subjects. It is conceivable that dwarf breeding stock might be used advantageously in the evaluation of techniques proposed for the identification of heterozygotes. Certainly such stock has a place in tests designed to establish the genetic relationship of the abnormality to other types of dwarfism in the same breed or to dwarfism in other breeds. Furthermore, the successful use of dwarf sires could materially reduce the length of time required to obtain progeny tests on phenotypically normal females. Dwarf males might also be of value, under some conditions, in testing for the presence of the dwarf gene in populations in which its presence has not been established. The authors did use one dwarf sire successfully for the latter purpose.

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[2] Contribution from the Western Regional Beef Cattle Research Project W–1, which is a cooperative research program involving all of the Western State Experiment Stations and the U.S.D.A.

[3] The authors express gratitude for the dwarf animals contributed by cooperating breeders, for the financial assistance and records supplied by the American Hereford Association, and for the efforts of Mr. Dan W. Clarke of Tucson in obtaining some of the experimental stock required. The veterinary assistance of Drs. W. J. Pistor, V. H. Fisher, and R. E. Reed is gratefully acknowledged. Thanks are extended to Mr. T. P. Jardine for a study of the dwarf pedigrees.

Materials and Methods

The majority of the dwarfs discussed in this paper were used primarily in a study of the inheritance of the anomaly in horned Hereford cattle as reported by Pahnish *et al.* (1955).

Complications that might have resulted from the introduction of comprest breeding were recognized. Precautionary measures taken to avoid the introduction of comprest breeding were outlined by Pahnish *et al.* (1955).

Prospective breeding animals of this recessive dwarf type were obtained after weaning, and primarily at ages of six to nine months, from herds in the Western and South Central states. A limited number were produced at the Arizona Experiment Station. At weaning time or upon arrival at the Station, these animals were placed in dry lot and developed on a ration of alfalfa hay fed *ad libitum*. Block salt was constantly available. The roughage ration was not changed except in individual instances discussed later in this report.

Due to circumstances rather than design, the dwarf bulls were at least 18 months of age when first used for breeding purposes. All services were performed by natural means, but a breeding chute or breeding pit was sometimes required.

The age at which the dwarf females were first served was dependent upon individual size and general thriftiness. Repeat services were often necessary. None of the virgin females were exposed prior to 17 months of age. The initial conceptions occurred at ages ranging from 18 to 30 months and within a weight range of 425–655 lb. All conceptions resulted from natural inseminations. Hand breeding was preferred, but it was soon found that some of the females showed little outward manifestation of estrus or that the estrus periods were extremely short. Due to a shortage of supervisory personnel, it was then considered advisable to expose these questionable animals continuously. With the exception of one Caesarean section, the births were by natural process.

Results and Discussion

The endeavor to employ Hereford dwarfs as experimental breeding animals was, at best, moderately successful. The difficulties encountered are discussed in the following paragraphs.

Dwarf Males

Histories of the six dwarf males, of which the experimental bull battery was comprised, are summarized in table 1. Three of these bulls

were obtained from privately owned herds and a like number were produced in the Experiment Station herd.

As indicated in table 1, three of the six dwarf males (bulls 8, 9, and 21) failed to develop into suitable breeding prospects due to chronic bloat or faulty locomotion.

Bloat tendencies were perceptible in bulls 8 and 9 at one month of

TABLE 1. THE HISTORIES OF SIX DWARF BULLS SELECTED AS POTENTIAL SIRES FOR THE EXPERIMENTAL BREEDING HERD

Animal number	Age at first breeding	Total conceptions	Remarks
	(months)		
5	18	5	Susceptible to a mild bloat condition. Died without prior evidence of any unusual disorder at 30 months of age. Bloat was not excessive at time of death.
8	..	..	Suffered from chronic bloat resulting in death at 9 months of age.
9	..	..	Suffered from chronic bloat. Sacrificed at 17 months of age.
10	22	18	Rendered incapable of natural service by weakness and lack of coordination in hind legs at age of 36 months. Sacrificed at 58 months of age.
21	..	..	Rendered unserviceable by stiffness in hind quarters. Eliminated from herd at 30 months of age.
26	30	2	Used to test for presence of the dwarf gene in a private herd.

age. By the age of three months, constant and extreme distentions, accompanied by general unthriftiness and loss of condition, were characteristic of both animals. Oral relief of the pressure was of temporary benefit to bull 8; bull 9, since the distention offered no apparent distress, was not treated. Changes from an alfalfa hay ration to rations of barley hay, oat or barley pasture, sudan grass pasture, or bermuda grass pasture failed to relieve the bloat conditions.

A general stiffening of the hind quarters was exhibited by bull 21 at 18 months of age, and the impediment became progressively worse. No

post-mortem evidence pointing out the specific cause of the disorder was found.

Three of the six dwarf bulls discussed in this paper (5, 10, and 26) were used as breeding animals and all were capable of reproduction. The total number of conceptions credited to each are shown in table 1. Bulls 5 and 10 were used on both dwarf and phenotypically normal females to obtain research data. Bull 26, was used only in a limited way for the purpose indicated in table 1. The latter animal, 51 months old and still serviceable when this report was prepared, is pictured in figure 1.

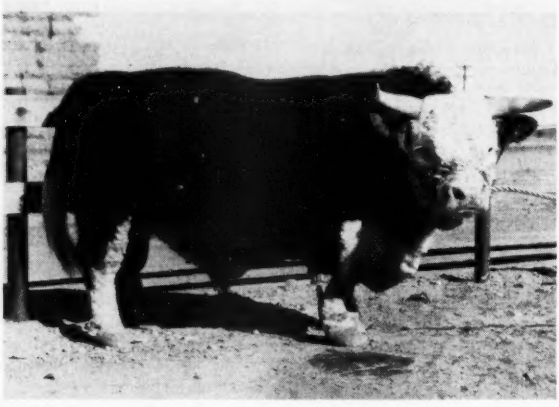

Figure 1. Dwarf bull 26 at 51 months of age. Height at withers, 110 cm.; weight, 1330 lb.

In view of evidence presented by previous authors, it is not surprising that the dwarf bulls used at the Arizona Station proved capable of reproduction. Carroll *et al.* (1951) stated that "dwarf calf pituitary caused as much gonad stimulation as normal pituitary." Johnson *et al.* (1950), upon examining the genital organs of a two-year-old dwarf male, found spermatozoa "in the sections of the ampulla of the ductus deferens." A few spermatazoa were found in one testicle of a dwarf bull slaughtered at 33 months of age by Lindley (1951). Lindley further reported that a dwarf bull apparently bred a dwarf female successfully.

Although some repeat services were required, this cast no serious reflection upon the dwarf bulls used by the Arizona Station. Difficulties were encountered only when dwarf females or virgin two-year-old females of normal phenotype were involved. The histories of the dwarf

females, presented later in this report, indicate certain reproductive irregularities. The virgin heifers of normal phenotype did not settle readily, but this is reasonably consistent with the findings of Lasley and Bogart (1943) and Burke (1954) in their studies of age effect on fertility in Hereford cattle. Hilder *et al.* (1944) and Tanabe and Salisbury (1946) also met with similar experiences while investigating the breeding efficiency of dairy cattle.

Even though bulls 5, 10, and 26 were considered successful breeders, the dwarf aberration did impose certain limitations. The reproductive lives of bulls 5 and 10 were limited, as shown in table 1. All three bulls were of short stature; activity was hampered by paunchiness and by the lack of proper muscular coordination. For these reasons, the breeding chute or breeding pit was usually required when phenotypically normal females were served. When the females were easily restrained, the open pit was preferable. As a general rule, the bulls hesitated to work in the breeding chute.

Dwarf Females

The histories of the ten dwarf females assembled in the experimental herd are summarized in table 2. Eight of these animals were obtained from private breeders in the Western states. The remaining two were produced at the Arizona Experiment Station.

Fifty percent of the afflicted females died of bloat or unestablished causes at ages ranging from 9 to 27 months and prior to gestation (table 2). The death of heifer 17 was attributed to chronic bloat combined with the stress due to shipment from an outlying state. Although heifer 13 apparently died of bloat also, this animal exhibited nothing more than a moderate susceptibility to the condition on occasions prior to that which resulted in death. Judging from the positions in which they were found, heifers 2, 12, and 14 died quite suddenly. Because of the rather complex dwarf syndrome, the specific disorders resulting in death were obscure in the three latter cases.

Although females 3, 6, 7, 11, and 15 conceived on one or more occasions, the first conceptions did not generally occur readily. Heifer 15, having conceived at 21 months of age as the result of the first service, was the exception to the rule.

When estrus was not detected by the age of 25 months, a retained corpus luteum was removed from heifer 3. This was followed by an intramuscular injection of anterior pituitary extract (5 ml.), and the animal was continually exposed to a dwarf bull thereafter. A post-mortem

TABLE 2. THE HISTORIES OF TEN DWARF FEMALES COMPRISING AN EXPERIMENTAL BREEDING HERD

Animal number	Natural life span (months)	Died prior to gestation	Died during gestation	Dropped premature calves	Gestation period completed	Phenotype of progeny [a]	Sire of progeny (phenotype)	Remarks
2	17	X	..	..	..	..	..	Immediate cause of death undetermined. Bloat not excessive.
3	31	..	X	..	..	Unk.	D	Conception followed removal of retained corpus luteum. Post-Mortem revealed badly decomposed fetus which may have been cause of death.
6	..	..	..	X	..	D	D	First calf, a heifer judged to have completed 8th month of development, died following delivery. Dystocia case. Second calf, aborted in 6th month of pregnancy, destroyed by predators. Cow removed from herd at 50 months of age because of total blindness.
				X		Unk.	D	
7	61	..	..	..	X	D	D	Three bull calves produced. All dystocia cases, and first two dead upon delivery. Third survived. Cow died of undetermined cause.
					X	D	D	
					X	D	D	
11	..	..	..	..	X	D	D	Heifer calf delivered by Caesarian section because of malpresentation. Calf died on 5th day after delivery. Cow failed to conceive during subsequent estrus periods, and was eliminated from herd at age of 39 months.
12	17	X	..	..	..	..	..	Immediate cause of death undetermined. Bloat not excessive.
13	24	X	..	..	..	..	..	Extreme bloat was apparent cause of death.
14	27	X	..	..	..	..	..	Immediate cause of death undetermined. Bloat not excessive.
15	31	..	X	..	..	D	D	Cow died on 293rd day of gestation and prior to onset of labor. Heifer calf removed following death.
17	9	X	..	..	..	..	..	Chronic bloat was apparent cause of death.

[a] Unk.—Unknown. D—Dwarf.

examination of heifer 3 revealed a decomposing fetus judged, by the examining veterinarian, to have been conceived about six weeks following the injection.

No evidence of estrus was noted in females 6 and 7 up to 23 and 20 months of age respectively. Palpations suggested that the genitalia were normal at these ages. When intramuscular injections of anterior pituitary extract (10 ml.) then obtained no response, like injections were again administered 30 days later. Both animals were continuously exposed to a dwarf bull. Heifer 7 apparently conceived a few days after the second injection, but heifer 6 was believed to have remained open until about six months following treatment.

Heifer 11, having developed satisfactorily, was first bred at 17 months of age; but conception did not occur until the third estrus period.

Death losses occurred not only prior to gestation but also during gestation. In the opinion of the examining veterinarian, a decomposing fetus could have caused the death of female 3 in about the fifth month of gestation. Female 15 died on the 293rd day of gestation and prior to the onset of labor. There was no specific evidence that gestation or related complications were responsible.

Data relative to the length of the gestation periods for dwarf females were limited. Since continual exposure of some females to the dwarf sires was found advisable, exact conception dates were not obtainable. Furthermore, only two of the females in the herd successfully completed one or more gestation periods. Cow 7 was known to have carried the second calf 291 days, and the third calf was apparently carried between 269 and 291 days. The first and only gestation period of cow 11 was 277 days in length. Cow 15 carried a calf through a gestation period of 293 days but died prior to the onset of labor. Only cow 6 gave birth to calves that were obviously premature (table 2).

The calving records of dwarf females 6, 7, and 11 suggest that the incidence of dystocia is high in such animals. Some very difficult parturitions indicate that Caesarean section should be considered as a means of reducing calf mortality.

Cow 6, although her first calf was premature and weighed only 38 lb. upon delivery, required assistance at parturition because of a breech presentation. This calf died within 15 minutes after delivery. Her second calf, also premature, apparently was dropped without serious complications (table 2).

Cow 7 gave birth to three calves by normal process, but all parturitions were complicated. In the first two cases, anterior presentations with the fore limbs completely or partially retained were encountered.

Stillbirths attributed to mechanical causes were the results. The third parturition was complicated by a breech presentation, but the calf was delivered alive and was successfully supported by the dam until weaned at six months of age. All three parturitions were further complicated by the relatively large size of the calves involved. These calves, all dwarf males, weighed from 60 to 76 lb. at birth. The dam weighed about 640 lb. when first bred and 850 lb. two weeks after the third calf was delivered.

A living dwarf female was obtained from cow 11 when the attending veterinarian, upon finding an anterior presentation with the hind feet nearly engaged in the pelvis, resorted to Caesarean section. The dam, in unusually good condition, weighed 600 lb. when bred. The calf weighed 52 lb. upon delivery. Although the calf died five days after birth, the death was not attributed to difficulties encountered at parturition.

The natural lives of the females in the dwarf breeding herd, cows 6 and 11 excepted, are shown in table 2. The reasons for eliminating the two animals indicated are shown in the table. It was found that the mortality rate was high; the causes of death and the ages at which death occurred were variable; the age of 61 months attained by cow 7 was exceptional for the females in this herd. The records suggest that the dwarf gene in the homozygous condition has a sub-lethal effect, beyond weaning age, which limits the value of dwarf females as research subjects.

Summary

The history of a herd of dwarf Herefords used in beef cattle breeding research was compiled. It was found that dwarf males and females could be used as research subjects although the aberration imposed the following limitations:

1. The mortality rate was high in both sexes, but the causes of death and ages at which death occurred were variable.

2. A relatively high incidence of bloat was noted. This somtimes resulted in death.

3. The dwarf bulls, in the performance of natural services, were hampered by their short stature, lack of muscular coordination, and paunchiness. A breeding chute or breeding pit was usually required when phenotypically normal females were bred.

4. The dwarf females did not conceive readily. This was particularly true of virgin heifers.

5. Difficult parturitions were characteristic of the aberrant females and usually resulted in the death of the offspring. To reduce calf mortality at birth, caesarean section may be the desirable method of delivery.

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PERFORMANCE TESTING OF BEEF BREEDING STOCK

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Texas Agricultural Experiment Station [2, 3]

A CONSIDERABLE volume of data has been accumulated during the past 15 years to indicate the heritability values of some economically important characteristics in beef cattle. The first published estimates of heritability of such characteristics were made by Knapp and Nordskog (1946a and 1946b). These estimates were calculated on the basis of data obtained from 177 steers sired by 23 bulls. They found by the parent offspring regression method a heritability value of 97 percent for rate of gain. They also calculated a similar value by the intra-sire or half-sib correlation method. Knapp and Clark (1947) reported a revised estimate of heritability based upon 422 steers sired by 52 bulls obtaining 72 percent for feed lot gains. Patterson *et al.* (1949) reported an intra-sire correlation of 0.26 based upon 807 bull progeny representing 113 sire groups. Knapp and Clark (1950) reported further revised estimates of heritability based upon 110 sire groups ranging from 65 percent by the half-sib correlation method to 77 percent by the regression of offspring on parent method. Kincaid *et al.* (1952) reported estimates of heritability of growth rate from 0 to 42 percent. These were based upon differences between fast and slow gaining pairs of sires and their steer progeny. Similar estimates from heifer progeny tested on pasture gave values of 0 to 20 percent. More recently reported values include estimates of 54 percent (Warwick and Cartwright, 1955) and 60 percent (Shelby *et al.*, 1955).

The purpose of this paper is to summarize the result of 12 years of feed lot performance tests conducted at the Balmorhea substation of the Texas Agricultural Experiment Station. The data and analyses reported here give additional information on the inheritance of growth rate in beef cattle, and emphasize the importance of considering the differential response of sires in different years.

[1] The authors express their appreciation to the many beef cattle breeders of the Davis Mountain and surrounding areas for the use of animals included in these tests and for their enthusiastic support of the work.

[2] In cooperation with the Animal & Poultry Husbandry Research Branch, A. R. S., U. S. D. A. and the State Experiment Stations under Southern Regional Project S-10, Beef Cattle Breeding Research.

[3] College Station.

Source of Data

A sire testing and individual evaluation program has been in progress continuously since the fall of 1942 at the Balmorhea substation of the Texas Agricultural Experiment Station. The program is conducted through a cooperative arrangement with beef cattle breeders, principally from the Davis Mountain region, whereby 2 to 8 bull calves or 2 to 8 heifer calves from each of one or more herd sires are entered on test. The average age of these animals at the beginning of the test is about 8 months, with a range of 6 to 12 months. These young animals are placed on test about the middle of November and are fed for approximately 140 days. The ration is self-fed in feeders especially designed for this purpose, and consists of a mixture of ground hegari bundles, ground alfalfa hay and cottonseed meal. The roughage composition of the ration is approximately 65 percent.

The animals are weighed at the beginning of the test, at 28-day intervals and at the close of the test. Each animal is given an initial and final type and body conformation score and a condition score by a panel of 2 to 4 judges. They are sorted into groups by sex according to weight, resulting in heavy, medium and light groups. The animals are fed together in lots that accommodate approximately 20 bulls or heifers each.

For the purpose of this study, only the Herefords are included, although a few animals of other breeds and crosses including Brahmans, Santa Gertrudis, Angus, and Beefmasters have been in the test. The data described in this paper include 1,053 bulls and 271 heifers representing 166 sire groups of bulls and 46 sire groups of heifers.

Results and Discussion

It was apparent in the early years of the tests that there were wide differences among sire groups of progeny as well as among individuals in their rates of feed-lot gains. In the analysis of the 11-year data, the extreme difference in average daily gains for sire groups within any one year was from 1.15 to 2.82 lb. per head daily, with a range of 1.67 lb. This is compared with 2.91 lb. per head per day difference between the lowest gaining (1.37 lb.) and the highest gaining (4.08 lb.) individuals within a year. It was further found that the standard error for progeny group average was 0.19 lb., which represents a range of 0.38 lb. within which approximately two-thirds of the group averages are expected to occur. The average daily gain for all animals in all years was 2.23 lb. These figures are given to show the ranges of variability among indi-

viduals and groups of individuals in rate of gain where the feeding and feed-lot management conditions are maintained as uniformly as possible. There were, likewise, wide differences in rates of gain from year to year.

To estimate the relative importance of heredity and environment as causative factors in these progeny group differences, correlation analyses were made within half-sib relationships. These intra-sire correlations obtained by analysis of variance methods were 0.325 for the bull progeny, 0.250 for the heifer progeny and 0.257 for all of the Herefords tested. The average number of progeny per sire were 6.74, 6.59 and 6.75 respectively. The rate of gain of half-sibs is more similar than would be expected if the characteristic were 100 percent heritable thus necessarily yielding an overestimate of the true heritability of this trait when calculated on the basis of the half-sib correlation.

One reason for the marked differences in feed-lot gains among progeny groups may be an influence of pre-test environmental conditions which varied from ranch to ranch but not as much within sire groups. Each progeny group came from a single ranch. There was not a sufficient number of multiple sire groups from the different ranches within years to allow an accurate estimate of the influence of pre-test environment.

There was considerable age variation among the sire groups and a significant, although slight, intra-sire age correlation. However, as shown in table 1, the relationship between age at the beginning of the test and average daily gain, although significant, was only 0.12 and could not be expected to contribute greatly to the gain differences among the progeny groups.

Pre-test management differed from ranch to ranch with some of the progeny groups receiving varying degrees of supplemental and creep feeding on the range. Furthermore, the condition of the range grasses in some areas was better than in others as a result of differential rainfall. All of these pre-test factors would be expected to affect the degree of fleshing or condition of the test calves as well as their initial weight. The relationship between condition and average daily gain, as shown in table 1, was —.24 indicating a tendency for thinner than average animals at the beginning of the test to gain faster than fatter ones. Although this correlation coefficient is significant, the relationship is slight and would not contribute greatly to the similarity of rate of gain within the progeny groups. The correlation between initial weight and average daily gain was only 0.11 and initial weight is partly a function of age as the correlation between the two was plus 0.63.

In estimating the heritability of gain, the assumption is made that

TABLE 1. CORRELATION COEFFICIENTS
(All Coefficients Were Calculated Within Year and Sex)

	Average daily gain		Initial weight		Initial age		Initial a grade		Final a grade	
Character	r [a]	df [b]	r	df	r	df	r.	df	r	df
Initial weight	.11**	1308								
Initial age	.12**	1061	.63**	1061						
Initial Condition c	—.24**	792	.40**	792	.18**	737	—.43**	770	—.33**	788
Initial Grade c, d	—.12	1218	+.40**	1218	—.02	1021				
Final Grade c, d	+.17**	1285	+.46**	1285	+.12**	1021	—.68**	1180		
Fineness of hair Grade d	+.01	1266								
Thickness of high grade d	+.04	1277								
Pliability of high grade d	—.02	1277								

[a] Correlation Coefficients.
[b] Degrees of freedom.
[c] The actual scores were taken on ascending scale with the more desirable animals being given lower numerical values. (However, for the purpose of consistency with initial score for condition the signs of the coefficients have been reversed).
[d] Average of subjective scores of several judges given at the beginning of the test.
** Significant at the 1 percent level.

the progeny resulted from strictly random matings; that there was no selection pressure favoring those animals with abilities for higher rates of gain. The low correlation coefficient of — 0.12 between initial grade and average daily gain indicates that pre-test selection based upon visual estimates of gaining ability was not a major factor affecting sire group differences. There is the possibility, however, that the usual amount of inbreeding found in the Hereford breed has resulted in different genetic lines with different hereditary potentials for rate of gain which were partially represented by the different sires and dams included in the tests. Furthermore, in choosing the progeny from the various sires to be included on the test, it is expected the cooperators would choose the most vigorous animals. This may have resulted in the selection of animals with above average potential gaining abilities through the elimination of the less thrifty ones.

Another factor which may have contributed to the high half-sib gain correlation is the likelihood that the dams of these progeny within ranches had a higher than average coefficient of relationship. A study of a sample of the pedigrees of progeny entered in the gain evaluation test showed that the average relationship of the half-sibs was closer to 0.33 than to 0.25 which is expected for half-sibs otherwise unrelated. The corrected estimates of heritability, assuming that all half-sibs were related to this degree, would be three times the intra-class correlation coefficient. Thus, $3(.3250)100 = 97.5$ percent and $3(.2496)100 = 74.88$ percent for the bulls and heifers, respectively.

In further efforts to investigate the causes of the obviously abnormally high estimates of heritability of gains from these data a determination was made of the interaction of sires and years. This component of variance has been assumed non-significant in the analysis reported and appears as a part of the variance identified as sires within years. It is obvious that if sire $\times$ year interaction variance is significant, the sires within years variance would be larger than the error variance, even though there was no difference between the sires.

In the present data, some of the sires were represented by progeny in several years and it was therefore possible to obtain an estimate of the sire component with the sire $\times$ year interaction component removed. For this analysis, the data were limited to bull progeny whose sires were represented in two successive or adjacent years or were separated by not more than one year. The number of progeny per sire per year ranged from 2 to 23, thus incorporating a bias as a result of disproportional sub-class numbers. The data were corrected for disproportionality

according to methods described by Snedecor (1946). Data from 18 separate combinations of years were analyzed which included a total of 98 degrees of freedom for the sire × year component and 1434 degrees of freedom for individuals.

The intra-class correlations from these analyses were tested for homogeneity by the method of chi-square. The probability that they could have been drawn from a homogeneous population was 0.99. These intra-class correlation coefficients were then averaged by the Z transformation method, resulting in a value of 0.1745. This average intra-class correlation coefficient when multiplied by 4 gave an estimate of heritability of 69.8 percent, a value considerably lower than those reported above. The estimate is further lowered if the average intra-class correlation is divided by 0.33 rather than 0.25, which, as previously indicated, is a more accurate estimate of the average relationship among half-sibs. The heritability estimate on this basis is 52.9 percent which is considered the most reliable estimate obtained from these data.

It is well recognized that heritability estimates based upon half-sib correlations are subject to considerable error since an error in the coefficient is multiplied fourfold in the estimate. Thus, the sire × year interaction, which is included as a part of a sire within year variance, even though relatively small and of no real practical significance, can cause an exaggerated overestimate of heritability. Of the 18 combinations of years analyzed only six were significant at the .05 level and only four of these at the .01 percent level.

The data included in this study do not allow for precise estimates of heritability, however, they have substantiated previous reports of high heritability of rate of gain in beef cattle and point to an improvement program based upon the utilization of performance records as a criterion of selection.

Rate and efficiency of gain along with reproductivity in beef cattle are the most important factors in the economics of beef production. Numerous research workers have reported high relationships between rate of gain and efficiency of gain. With the selection of breeding animals based upon their individual performance for rate and economy of gain, an increased volume of meat can be produced at reduced costs. However, what effect will this increased volume of more efficiently produced beef have on the quality of the meat? Are there live animal characteristics that are indicative of meat quality and if so are they heritable? Although, from the data collected in these tests there are no indications that body characteristics are closely related to gaining ability, further study will

determine the factors affecting quality. But first, meat quality itself must be more accurately defined and objectively measured. These problems are now being explored in the meats research of the Texas Agricultural Experiment Station as a part of the beef breeding program. These researches are expected to lead to a better understanding of the factors affecting the total beef production problem, including the consumers requirements and demands for meat.

Summary

A program of testing young breeding beef cattle for gaining ability has been conducted since 1942 at the Balmorhea substation. The cattle start on test at 6 to 12 months of age and are self-fed a ground, mixed ration of about 65 percent roughage for a total period of about 140 days. Only data from Herefords were analyzed in this study, which included 1,053 bulls in 166 sire groups and 271 heifers in 46 sire groups. Wide differences in gaining ability were found, ranging from 1.15 to 2.82 lb. per head daily for the average of the sire groups and from 1.37 to 4.08 for individuals. Intra-sire correlation coefficients between half-sibs were 0.3250 and 0.2496 for bulls and heifers, respectively. Several possible causes for these obviously overestimated values are discussed although the data do not allow much precision in estimation. It appears that subsequent gain is little affected or associated with initial grade, initial weight or initial age within the limits of this study and performance records are apparently not greatly biased by these factors. The respective correlation coefficients between subsequent gain and the above three variables are 0.12, 0.11 and 0.12. The correlation coefficient between initial condition and subsequent gain is higher (0.24) and may bias results in extreme cases. On the assumptions of half-sib relationships of 0.25 and zero sire $\times$ year interaction, the data gave unrealistically high heritability estimates. When the actual half-sib relationship of 0.33 was used and the sire $\times$ year variance removed from apparent sire differences, a heritability estimate of about 53 percent for rate of gain in the feed-lot was obtained. Further discussion is included concerning the relationship of rate of gain to other economic characters and the impact on the beef-producing industry.

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THE EFFECT OF PARTICLE SIZE ON THE UTILIZATION OF BONE MEAL AND LIMESTONE BY BEEF CATTLE [1]

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BEEF cattle rations consisting of natural feeds frequently are inadequate in calcium and/or phosphorus. These minerals are usually furnished to animals by one or more mineral supplements. Mineral supplements are usually obtained in granular or powdered form to facilitate uniform mixing with the feeds. The degree of fineness to which these mineral supplements are prepared is quite variable. When they are finely powdered the grinding cost is increased, loss by blowing is greater and the product is dusty and disagreeable to handle.

The objective of this study was to determine the effects of texture or the fineness of grind of limestone and bone meal on the utilization of calcium and/or phosphorus by growing beef cattle.

Two trials which compare coarsely and finely ground bone meal and limestone are reported. The comparisons were measured by feed lot performance of steers, blood calcium and phosphorus studies and the breaking strength of certain bones. To supplement these data and to further clarify the effect of the texture of mineral supplements upon the utilization of the mineral elements in question the radioisotope technique was used in a third trial.

Experimental

Trial 1

Twenty head of medium to good steer calves were divided into four lots of five animals each and group-fed a ration consisting of feeds relatively low in calcium and phosphorus. The grain mixture consisted of 40 percent dried molasses beet pulp and 60 percent ground shelled corn. The rations fed to the steers in lots 1 and 2 were supplemented with finely and coarsely ground limestone, respectively. Supplemental phos-

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[2] The feeding experiments reported in this article were conducted at the Nebraska Exp. Sta. and the isotope studies at UT-AEC Agr. Res. Program, Oak Ridge, Tenn.

TABLE 1. SUMMARY OF WEIGHT GAINS, FEED INTAKES AND BONE ANALYSES

	Trial 1				Trial 2			
Lot number	1	2	3	4	5	6	7	8
Texture of mineral supplement	Limestone		Bone meal		Limestone		Bone meal	
	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Feed lot data:								
Av. initial weight, lb.	564	569	572	568	553	553	553	553
Av. final weight, lb.	982	1021	1023	1049	1015	1013	1031	1001
Av. daily gain, lb.	1.99	2.15	2.15	2.29	1.75	1.74	1.81	1.70
Average daily ration, lb.[a]:								
Corn and dried beet pulp	14.2	14.2	14.2	14.2	12.3	12.2	12.3	12.3
Urea	0.166	0.166	0.165	0.165	0.17	0.16	0.16	0.16
Corn meal	1.0	1.0	1.0	1.0				
Limestone	0.099	0.099			0.12	0.12		
Dicalcium phosphate	0.211	0.211						
Disodium phosphate					0.08	0.08		
Bone meal			0.279	0.279			0.14	0.14
Ground corn cobs					4.8	4.7	4.8	4.7
Prairie hay	6.6	6.6	6.6	6.6	1.3	1.3	1.4	1.4
Slaughter and carcass data:								
Dressing percent (warm)	62.06	61.78	61.69	61.75	59.35	61.61	60.24	61.36
Carcass grades:								
Choice	4	4	4	5	2	4	4	6
Good	1	1	1	0	4	2	2	0
Bone breaking strength, lb./square inch	29,013	27,551	26,894	26,714	25,304	24,959	25,875	25,822
Bone calcium [b]	35.6	36.1	36.0	36.1	35.2	35.1	35.4	35.9
Bone phosphorus [b]	16.1	15.8	16.0	16.0	15.4	15.8	16.0	16.0

[a] Each animal received 20,000 I.U. of vitamin A.
[b] Percent calcium and phosphorus in bone ash on moisture-free, fat-free basis.

phorus was furnished by dicalcium phosphate. The rations fed in lots 3 and 4 were supplemented with finely and coarsely ground steamed bone meal, respectively. The finely and coarsely ground limestone and bone meal supplements were separated through a 28-mesh screen. The particles which did not pass through the screen were retained as coarsely ground. The particles which passed through were considered finely ground limestone or bone meal and the general texture of the materials was somewhat similar to flour or starch.

To supplement the protein in the basal ration consisting of corn, dried beet pulp, and prairie hay, urea was added in amounts as indicated in table 1. The dried beet pulp and corn mixture was gradually increased during the feeding period while the mineral-urea-corn meal (carrier for the mineral and urea) mixture was kept constant throughout the test. The latter mixture was as follows (by weight): Mixture for lots 1 and 2: 11.21 percent urea, 14.24 percent dicalcium phosphate, 6.72 finely or coarsely ground limestone, and 67.83 percent corn meal: Mixture for lots 3 and 4: 11.43 percent urea, 19.36 finely or coarsely ground bone meal and 69.20 percent corn meal.

A vitamin A supplement was also added to the grain mixture in all lots at a rate of 20,000 I. U. per head daily in both trials.

Trial 2

Twenty-four head of medium to good quality steer calves were used in the second feeding trial. During the first 78 days of the feeding trial, the four lots of steers were fed the same ration consisting of 13.96 percent dried molasses beet pulp, 32.56 ground shelled corn, 46.50 ground corn cobs, 1.16 urea, and 5.80 percent corn meal. The corn meal was used as a carrier for urea and also for the minerals that were added to the ration in the latter part of the feeding test. Ground corn cobs, rather than prairie hay, were used in this trial during the individual feeding period because of convenience in mixing. This change controlled the variation in roughage and concentrate consumption. When the steers had been fed the above mixture for 60 to 70 days, symptoms of calcium and phosphorus deficiency were recognized. After 78 days of group feeding the steers were individually fed the basic ration with the respective mineral supplements added at a rate equivalent to nearly twice the minimum allowance recommended by the National Research Council (1950). The 12 steers (six head on fine-textured limestone and six on coarse-textured limestone) received their supplemental phosphorus from disodium phosphate. By using disodium phosphate instead of dicalcium

phosphate as used in the first trial the calcium and phosphorus ratio was held more closely in line with that in bone meal. The steers in lots 7 and 8 received their supplemental calcium and phosphorus from fine- and coarse-textured bone meal, respectively.

Since the steers were not in suitable market condition to sell as fat cattle after 123 days of individual feeding, they were group-fed by lots for an additional 63 days. A grain mixture of 40 percent dried molasses beet pulp and 60 percent ground shelled corn was fed. To this mixture was added the following (by weight): To lots 5 and 6: 10.62 percent urea, 14.20 percent limestone (lot 5, fine-texture; lot 6, coarse-texture), 10.78 percent disodium phosphate, 0.29 per cent vitamin A supplement, and 64.11 percent corn meal (carrier for above ingredients); and to lots 7 and 8: 11.42 percent urea, 19.33 percent bone meal (lot 7, fine-texture; lot 8, coarse-texture), 0.31 percent vitamin A supplement, and 68.94 percent corn meal.

Ground corn cobs were withdrawn from the ration during the latter 63 days and prairie hay was fed at the rate of approximately 4 lb. per head daily.

Results. Table 1 summarizes the results of the experiments. In the first trial, the animals which were fed the coarse-textured mineral supplements gained more rapidly than those which received the fine-textured supplements. However, in the second trial there was very little difference, in fact the steers which were fed finely ground bone meal as the mineral supplement gained 0.11 lb. more per head daily than those fed coarsely ground bone meal. The small differences in gains and the similar daily feed consumption by the steers showed very little effect on the efficiency of feed utilization.

Bone samples were taken from the right foreshank of each steer at the time of slaughter. A longitudinal section measuring 3½ inches in length, 0.391 to 0.510 inches in width and 0.197 to 0.270 inches in depth was taken near the center of the shank. A South Work-Emery Loading device was used to measure the breaking strength of the fresh bone samples, and the following formula was used for the calculations: pounds per square inch $= \frac{5.25\ P}{BH^2}$, where P = load recorded on the device, B = width of sample and H = depth of sample. The results shown in table 1 indicate very little difference in the breaking strength of the bones as affected by the feeding of fine- or coarse-textures of bone meal or limestone.

In trials 1 and 2 the blood calcium level remained very uniform

throughout the test. The particle sizes of the limestone or the bone meal apparently had no effect on the availability of calcium. The availability of blood phosphorus also was not affected by the particle size of the mineral supplements which were added. However, the blood phosphorus level fluctuated as the phosphorus content in the ration was increased or decreased. These fluctuations occurred in all four lots fed the different textures of mineral supplements. The average initial blood phosphorus level for the twenty experimental animals in trial 1 was 6.9 mg. per 100 ml. serum and 7.6 mg. in trial 2. The phosphorus supplements were added to the ration at the beginning of the experiment in trial 1 and as shown in figure 1, there was an increase in the phos-

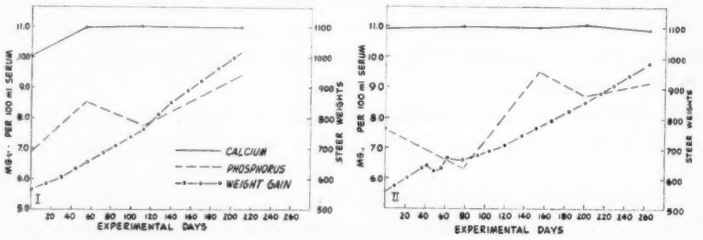

Figure 1. Average blood calcium and phosphorus levels and body weight increases of steers. I trial 1, II trial 2.

phorus level when the blood samples were taken 56 days later. In trial 2 feeding a ration which was lower than the recommendations of the National Research Council (1950) by 46 percent for phosphorus and 61 percent for calcium lowered the serum phosphorus from an average of 7.6 mg. per 100 ml. to 6.3 mg. in a period of approximately 70 days. When the mineral supplements were added to furnish more than the recommended allowances the serum phosphorus reached a level of 9.5 mg. within 80 days.

Trial 3 (Isotope Studies)

Two yearling Hereford steers and two Hereford calves were fed experimental rations as shown in table 2, in a double reversible paired feeding experiment. For each trial one animal from each pair received the basal ration plus the *coarse* and the other animal received the basal ration plus the *fine* limestone calcium supplement. The ration composition and chemical analyses are shown in tables 2 and 3. The calves received 2 lb. of hay and 6 lb. of concentrates daily whereas the yearlings received 3 and 10 lb., respectively. The level of feeding was established two weeks prior to and remained unchanged throughout the experiment.

TABLE 2. PERCENTAGE COMPOSITION OF FEED RATIONS

Concentrate ingredient	Ration M-1 (calves)	Ration M-2 (yearlings)
Corn	65.04	67.8
Oats	21.68	22.6
Cottonseed meal	12.39	9.0
Yeast [a]	0.01	0.01
Limestone	0.88	0.61

[a] Supplied 1500 I. U. vitamin D.

Details of analytical methods have been described by Comar *et al.* (1951) and general procedures for handling of animals by Hansard, Comar and Plumlee (1951). Endogenous calcium levels were determined by the isotope dilution method as described by Visek *et al.* (1953). In brief, each animal was trained to the metabolism stall until it was eating and behaving normally. For ten consecutive days, 0.15 to 0.30 mc. of radio-calcium as the chloride was administered daily by intravenous injection. For ten days after the last injection, fecal and blood samples were taken for chemical and radiochemical analyses. These values plus the feed intake data were used to calculate the calcium balance, the fecal endogenous calcium losses and the "true" digestibilities of the dietary calcium. Thirty days later the rations were reversed and the experiment repeated except that only the ordinary calcium balance was determined.

Experience had shown that the fecal endogenous calcium loss was directly correlated with body weight. The agreement was sufficiently good between the experimental values in the first run and the values calculated from body weight, that it was considered satisfactory to use calculated values for the second run.

Results. The results are presented in table 4 and are expressed in terms of true digestibility of all the calcium in the ration. Previous studies using similar basal rations indicated that the true digestibility for calcium ranged from 34 to 41 percent (Hansard, Comar and Plumlee,

TABLE 3. CHEMICAL ANALYSIS OF RATIONS [a]

Sample	Dry Matter	Ash	Calcium	Phosphorus
	%	%	mg./gm.	mg./gm.
Conc. + fine limestone	88.1	2.60	3.37	1.93
Conc. + coarse limestone	88.1	2.75	4.06	1.80
Hay	...	...	4.1	...

[a] Values are on fresh weight basis and represent averages of 14 analyses each except for hay. Differences between M-1 and M-2 rations were so small that the results were pooled to give above.

1954). Since this was close to the over-all values in table 4, there was no advantage to be gained from estimation of the availability of the limestone calcium separate from that of the basal ration. Also, the limestone supplement did supply the major part of the calcium, over 80 percent. Thus, the true digestibility values in table 4 may be regarded as a fair measure of the availability of the particular calcium supplement.

It is clear that there were no appreciable differences between the availabilities of the fine- and coarse-textured limestone.

TABLE 4. SUMMARY OF COMPARATIVE AVAILABILITIES FOR CATTLE OF CALCIUM FROM COARSE- AND FINE-TEXTURED LIMESTONE

Animal No.	398	398	280	280	211	211	209	209
Supplement	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Ration	M-1	M-1	M-1	M-1	M-2	M-2	M-2	M-2
Weight (lb.)	314	323	376	365	765	793	788	752
Balance run [a]	I	II	II	I	I	II	II	I
Ca intake (gm./day)	15 4	15.3	13.5	15.2	20.1	23.1	19.2	22.8
Ca excretion (gm./day)	11.8	10.1	10.8	12.0	15.1	18.9	17.4	14.5
Fecal end. ca (gm./day)	2.1	2.2	2.7	2.7	4.9	4.9	4.6	4.5
Apparent digest.[b]	24	34	20	31	25	18	10	36
"True" digest.[c]	37	48	40	39	49	39	33	56

[a] Balance run I was from 8/28 to 9/8/53 and run II was from 9/18 to 9/28/53.

[b] Apparent digestibility $= \dfrac{\text{calcium intake} - \text{fecal calcium}}{\text{calcium intake}} \times 100$

[c] True digestibility $= \dfrac{(\text{Calcium intake} - \text{fecal calcium}) + \text{fecal endogenous calcium}}{\text{calcium intake}} \times 100$

Summary and Conclusions

Two feeding trials and a radioisotope experiment were conducted to determine the effect of particle size of limestone and bone meal on the utilization of calcium and/or phosphorus by growing beef cattle. The comparisons in the utilization of the mineral supplements of different textures in the two feeding trials were measured by the feed lot performances, blood calcium and phosphorus studies and breaking strength of bones. Radioactive calcium was used to determine the availability of calcium from fine- and coarse-textured limestone in a separate experiment.

The results obtained in the feeding trials and the isotope experiment indicate that the coarse- and fine-textured limestone and bone meal were of equal value as mineral supplements for growing beef cattle.

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THE SUBCUTANEOUS IMPLANTATION OF STILBESTROL IN FATTENING BULLS AND STEERS

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IT has been shown that bull calves make more rapid and economical gains than steer calves when fattened in dry lot (Klosterman *et al.*, 1954). Bulls, however, were more difficult to fatten and graded significantly lower when slaughtered.

The subcutaneous implantation of stilbestrol promotes fattening in poultry (Sykes *et al.*, 1953) but tends to lower the carcass grade of steers and heifers (Dinusson, Andrews and Beeson, 1950; Sykes *et al.*, 1953; Clegg and Cole, 1954). The effect of stilbestrol implantation upon the growth and fattening of bull calves has not been reported.

The experiments reported here were initiated to study the influence of stilbestrol treatment upon the fattening of bull calves and to compare the feed-lot performance of steers and bulls.

Procedure

1952–1953 Experiment

A carload of high quality Hereford bull calves was purchased in Texas for this experiment. Eight head were castrated on October 16 and fed as a lot of control steers. Previous work (Klosterman *et al.*, 1954) has shown that calves castrated at this age, 7 to 8 months perform in the feed lot like those castrated shortly after birth. Five bulls were fed for 98 days, castrated, and then fed for an additional 98 days. Five other bulls were implanted subcutaneously in the neck region with 84 mg. of stilbestrol, fed for 98 days, given a second implantation of 132 mg. of stilbestrol and fed for an additional 84 days. Ten bulls were fed for 98 days, implanted with 132 mg. of stilbestrol and fed for 98 days. Ten other bulls were fed without castration or other treatment for the entire experiment.

1953–1954 Experiment

Two lots of 10 steers and two lots of 10 bulls each were fed in this experiment. The bulls and steers were obtained from the same source as those fed in the previous experiment. One lot of each of the bulls and

[1] Wooster, Ohio.

steers was implanted with 84 mg. of stilbestrol per head on December 16, 1953, and again with the same dosage on March 12, 1954. The implantations were made subcutaneously in the mid-portion of the ear.

The cattle in both experiments were full fed in an open shed with access to outdoor dry lots. The average daily rations are included in tables 1, 2, and 3. The mineral supplement was a mixture of two parts steamed bone meal, two parts ground limestone, and one part salt, by weight.

TABLE 1. FEED LOT PERFORMANCE OF STEERS, BULLS, AND STILBESTROL IMPLANTED BULLS

1952–53 Experiment, Period I Oct. 22, 1952, to Jan. 28, 1953

Items	Steers	Bulls	Bulls	Bulls, stilbestrol implant 10/22/52	Bulls
Number in lot	8	10	10	5	5
Weight, Oct. 22, 1952, lb.	410.00	414.00	421.00	417.00	422.00
Weight, Jan. 28, 1953, lb.	608.50	649.00	647.00	674.00	654.00
Av. daily gain, 98 dy.	2.03	2.40	2.31	2.62	2.36
Av. daily ration					
Corn and cob meal, lb.	8.2	8.0	8.2	8.0	7.6
Soybean oil meal, lb.	1.5	1.5	1.5	1.5	1.5
Hay, lb.	2.8	2.9	2.9	2.8	2.8
Corn silage, lb.	5.0	5.0	5.0	5.0	5.0
Minerals, oz.	.6	.5	.5	.5	.5
Salt, oz.	.6	.5	.5	.5	.5
Feed per cwt. of gain					
Corn and cob meal, lb.	405.50	332.00	355.00	305.00	322.00
Soybean oil meal, lb.	74.00	62.50	65.00	57.00	64.00
Hay, lb.	140.00	121.00	128.00	106.00	117.00
Silage, lb.	248.00	210.00	218.00	192.00	213.00
Minerals, lb.	2.00	1.00	1.00	1.00	1.00
Salt, lb.	2.00	1.00	1.00	1.00	1.00

All the cattle fed in the 1952–1953 experiment and five representative animals from each lot in the 1953–1954 experiment were slaughtered through the Meats Laboratory at Ohio State University. Those animals in the second experiment which were not sent through the Meats Laboratory were slaughtered by a Columbus packing company where carcass grades and dressing percentages were obtained.

One animal was removed from the lot of stilbestrol-treated steers in the 1953–1954 experiment because of acute laryngitis of a severe

nature. This malady was diagnosed as not being related to the stilbestrol treatment.

TABLE 2. FEED LOT PERFORMANCE OF STEERS, BULLS, AND STILBESTROL IMPLANTED BULLS

1952–53 Experiment, Period 2 Jan. 28, 1953, to May 6, 1953

Items	Steers	Bulls, stilbestrol implant 1/29/1953	Bulls	Bulls, stilbestrol implant 10/22/1952 and 1/29/1953	Steers castrated 1/29/53
Number in lot	8	10	10	5	5
No. days on experiment	98	98	98	84	98
Weight, Jan. 28, 1953, lb.	608.5	649.0	647.0	674.0	654.0
Final weight, lb.	816.0	907.0	877.0	904.0	834.0
Av. daily gain, lb.	2.12	2.63	2.34	2.75	1.84
Av. daily ration					
Corn and cob meal, lb.	10.8	11.7	10.9	12.2	10.4
Soybean oil meal, lb.	1.5	1.5	1.5	1.5	1.5
Hay, lb.	2.3	2.4	2.4	2.2	2.2
Corn, silage, lb.	5.0	5.0	5.0	5.0	5.0
Minerals, oz.	.4	.6	.6	.8	.7
Salt, oz.	.4	.5	.5	.8	.7
Feed per cwt. of gain					
Corn and cob meal, lb.	511.0	445.0	465.0	446.0	567.0
Soybean oil meal, lb.	71.0	57.0	64.0	55.0	81.0
Hay, lb.	106.0	91.0	102.0	81.0	119.0
Corn silage, lb.	236.0	190.0	213.0	182.0	270.0
Minerals, lb.	1.0	1.0	2.0	2.0	2.0
Salt, lb.	1.0	1.0	1.0	2.0	2.0
Dressing percentage	59.5	60.0	58.8	59.6	58.2
Av. carcass grade [a]	1.33	2.09	2.01	1.64	1.82
Edible portion, percent of carcass	73.2	77.3	77.1	75.8	73.9

[a] Carcass grade factor—Choice 1, 1.4, 1.7 Good—2, 2.4, 2.7

Results

The results obtained during the first 98 days of the 1952–1953 experiment are presented in table 1 and for the remainder of the experiment, in table 2. Table 3 presents the results of the 1953–1954 experiment.

Average Daily Gains

In the first 98-day period the average daily gain of all untreated bulls was 2.36 lb., which was 0.33 lb. per day faster than the steers. The five stilbestrol-treated bulls gained 0.26 lb. per head daily faster than the average of all untreated bulls.

TABLE 3. EFFECT OF STILBESTROL UPON THE FEED LOT PERFORMANCE OF STEERS AND BULLS

1953–1954 Experiment

Items	Bulls, stilbestrol implant	Bulls	Steers, stilbestrol implant	Steers
Number in lot	10	10	9	10
Av. weight, Dec. 16, 1953, lb.	532.0	529.0	555.0	555.0
Av. weight, June 2, 1954, lb.	1028.0	992.0	1021.0	943.0
Av. Daily gain, 168 days, lb.	2.96	2.76	2.79	2.31
Av. daily ration, lb.				
Corn and cob meal	12.6	11.0	11.8	11.5
Soybean oil meal	1.5	1.5	1.5	1.5
Corn silage	10.0	10.0	10.0	10.0
Hay	1.9	1.9	1.9	1.9
Minerals, oz.	.4	.4	.4	.4
Salt, oz.	.4	.4	.4	.4
Feed req. per cwt. of gain, lb.				
Corn and cob meal	428.0	399.0	425.0	497.0
Soybean oil meal	51.0	54.0	54.0	65.0
Corn silage	338.0	363.0	357.0	433.0
Hay	63.0	68.0	67.0	80.0
Minerals	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0
Dressing percentage	61.6	61.2	61.3	61.5
Av. carcass grade [a]	2.03	2.47	1.62	1.37
Edible portion, percent of carcass [b]	75.0	76.1	72.0	69.9

[a] Carcass grade factor—Choice 1, 1.4, 1.7 Good—2, 2.4, 2.7

[b] Determined on five representative carcasses from each lot.

During the second period of the first experiment the two lots of steers gained at the average rate of 2.01 lb.; the bulls, 2.34 lb., and the bulls treated with stilbestrol, 2.67 lb. per head daily. These differences, 0.33 lb. in both instances, proved to be statistically highly significant. Castration of the five bulls on January 29 retarded their gains for a time so that their average daily gain for the period was 0.28 lb. slower than that of the lot of steers castrated prior to the start of the experiment.

The differences in average daily gains between the bulls and steers and between the stilbestrol treated and untreated animals in the second experiment were significant at the one percent level. The implantation of stilbestrol brought about a greater increase in daily rate of gain of the steers, 0.48 lb., than of the bulls, 0.20 lb. The stilbestrol-treated steers gained at much the same rate as the untreated bulls.

Appetite

There was no consistent difference in feed consumption between the various lots of cattle during the first period of the 1952–1953 experiment. In the second period, the bulls ate slightly more ground ear corn than the steers and the stilbestrol-treated bulls ate noticeably more. In the 1953–1954 experiment the implanted steers ate 0.3 lb. more ground ear corn than the untreated steers and the stilbestrol-treated bulls ate 1.6 lb. more than the control bulls. Thus, the stilbestrol treatment brought about a definite increase in appetite. These results are in agreement with those published previously (Clegg *et al.*, 1954; Andrews, Beeson and Johnson, 1954).

Carcass Data

The dressing percentages, carcass grades and percentages of edible portion obtained in these experiments are presented in tables 2 and 3. Although there were no significant differences in dressing percentages between the various lots, a previous comparison of steers and bulls (Klosterman *et al.*, 1954) showed that bulls had a significantly lower carcass yield than steers.

As noted in the previous studies, the bull carcasses produced in the present experiments graded significantly lower than the steer carcasses. The carcass grades as presented in table 2 are averages for the lots. The animals, however, were not all slaughtered at the same time, and some of the differences were actually greater than appear in these averages. This was especially true in the comparison of untreated bulls and the bulls which had received two implantations of stilbestrol. The average difference between these two groups was 0.37 of a grade. However, the carcass grades of five untreated bulls averaged 0.72 of a grade lower than the five stilbestrol-treated bulls which were slaughtered at the same time.

The lowest carcass yield in the first experiment was from the steers which had been castrated in January. Their carcasses also graded approximately half a grade lower than the other lot of steers.

Analysis of variance of the carcass grades obtained in the 1953–1954 experiment showed a highly significant difference between steers and bulls, with the bulls having the lower grade. There was also a significant interaction between castration and stilbestrol treatment. The implantation of stilbestrol significantly increased the carcass grade of the bulls, 0.44 of a grade, but lowered the grade of the steer carcasses by one-fourth of a grade.

The edible portion data given in tables 2 and 3 were obtained by separating one-half of each carcass into bone, fat trim, and edible portion. The edible portion of the carcass is designated as edible meat with no more than three-eighths inch layer of fat on any surface. As noted in previous comparisons of steers and bulls at the Station, the bull carcasses in these experiments produced the higher percentage of edible portion. These differences were significant at the one-percent level. In the second experiment, there was a significant interaction between castration and stilbestrol treatment. The implantation of stilbestrol increased the amount of edible meat in the steer carcasses but reduced it in the bull carcasses. This relationship is the direct opposite of what was found in carcass grade, and shows the influence of degree of finish of a carcass upon its yield of edible portion.

Sexual Development and Behavior

Under the conditions in which the animals were fed in these experiments, there was no noticeable difference between the various lots in amount of restlessness in the feed lot or in handling the animals during feeding and weighing. Although stilbestrol brought about some definite changes in appearance of the animals it did not noticeably affect their activity.

The implantation of stilbestrol in weanling bull calves caused some retardation in sexual development. Although there was individual variation in response, the treated bulls generally did not develop as heavy a crest or as masculine a head as the untreated bulls. There was also some depression of testes growth and stimulation of teat development in the treated bulls. The implantations also caused an elevation of the tail head in both bulls and steers. Some of these changes are illustrated in Figure 1. Pictured is a representative bull from the lot which received two implantations of stilbestrol in the 1952–1953 experiment. The picture was taken 154 days after the start of the experiment. During this period this bull gained 2.60 lb. daily which was only slightly under the average for that lot.

Discussion

The implantation of stilbestrol pellets in fattening bull calves gave results similar to those reported from the treatment of steers and heifers, except for the effect on carcass grade. Stilbestrol generally has decreased the carcass grade of steers and heifers, while in these experiments it significantly increased the grade of fattening bulls. The response in rate of gain of bulls to stilbestrol treatment was greater in the first experiment when larger dosages were used than in the second experiment.

Figure 1. Representative bull from group which received two implantations of stilbestrol, 1952–1953 experiment. Note elevated tail head, teat development, and subnormal development of crest and masculinity of head.

Although these experiments did not include any direct comparison of different levels of treatment, it may be possible that larger amounts of stilbestrol would further stimulate gains, retard sexual development and improve the carcass grade of fattening bulls. However, in limited observations made at this Station, implantations of 60 mg. of stilbestrol in young, suckling bull calves running with their dams on pasture did not noticeably affect sexual development or rate of gain.

The increased rate and economy of gain of bull calves over steer calves noted in these experiments is in agreement with a previous publication (Klosterman *et al.*, 1954). With the current feed and beef supplies available in this country, the practical application of this information may be questionable. However, in areas where meat supplies are limited, or if a shortage should develop in this country in the

future, it seems quite clear that the supply of good to choice quality beef could be very quickly and markedly increased by the elimination of castration and by the use of stilbestrol to further increase production and improve quality.

The response obtained from stilbestrol treatment of steers in the second experiment is in agreement with previously published information (Sykes *et al.*, 1953; Andrews, Beeson and Johnson, 1954; Clegg and Cole, 1954). It has also been shown that an oral administration of approximately 10 mg. of stilbestrol per head daily gave a similar growth response (Burroughs *et al.*, 1954, a, b; Culbertson *et al.*, 1954; Perry *et al.*, 1955).

Although performed on only a limited number of animals in the 1952–1953 experiment, castration during the middle of the feeding period does not appear to be a practice to be recommended. Castration at this time markedly reduced the rates of gain, increased feed costs and produced carcasses very similar to those from bulls.

Summary

In dry lot fattening trials bulls gained more economically and significantly faster than steers. The subcutaneous implantation of stilbestrol significantly increased the rate of gain, this increase being greater in steers than in bulls. Stilbestrol treatment significantly increased the grade of bull carcasses but reduced slightly the grade of steer carcasses. There appeared to be no advantage in feeding bulls for a period, castrating, and finishing as steers.

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INTERCORRELATIONS OF WEIGHTS OF WHOLESALE CUTS OF BEEF CARCASSES [1]

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A STUDY of the intercorrelations of the weights of wholesale cuts of beef carcasses is of apparent importance because during the process of appraising cattle by visual means, use is frequently made of expressed or implied correlations of comparative cutout values of different parts of the animal. A survey of available literature as well as personal communication with a number of meat specialists [6] indicated that apparently studies of the intercorrelations of the weights of the wholesale cuts of beef have not been reported.

Materials and Methods

The steers available for this study as well as the cutting and other procedures used have been described in detail by White and Green (1952). Fifty steers ranging in live weight from 800 to 1,445 lb. and grading mainly choice and good (old standard) were slaughtered, and the wholesale cuts of their carcasses were removed according to the procedures given by the U. S. Office of Price Stabilization (Anonymous, 1951). The weights used represent the combined weights, to the nearest one-quarter pound, of each cut taken from each side of the carcass. Yields of some of the individual cuts were added as indicated. Live weight was measured to the nearest five pound unit. Slaughter grade was estimated on the basis of U.S.D.A. standards (Burk and Whalin, 1942). Zero order and first and second order partial correlations were computed by use of methods given by Snedecor (1948).

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[5] Animals, slaughtering, and cutting of carcasses were furnished through the courtesy of the Corkran-Hill Company, Baltimore, Maryland.

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Results

The means, standard deviations, and coefficients of variation for the cuts [7] as well as live weight and slaughter grade are presented in table 1. The coefficients of variation of the cuts are quite similar in magnitude with the exceptions of the flank and kidney knob.

Most of the zero order correlations in table 2 are statistically significant and rather large in magnitude; the only exceptions being among

TABLE 1. MEANS AND STANDARD DEVIATIONS OF MEASUREMENTS TAKEN ON LIVE STEERS AND WHOLESALE CUTS OF THEIR CARCASSES

Measurement or cut	Item No.[a]	Mean [b]	Standard deviation [b]	Coefficient of variation
				%
Live weight	(1)	1118.80	158.18	14.1
Slaughter grade	(2)	5.82	1.30	22.4
Rib	(19)	53.07	8.87	16.7
Short plate	(55)	52.73	9.85	18.7
Brisket	(57)	29.92	5.78	19.3
Arm chuck	(58)	193.59	28.22	14.6
Cross cut chuck (57 + 58)	(26)	223.51	33.42	15.0
Fore quarter	(59)	329.31	50.23	15.3
Short loin	(6)	49.35	8.49	17.2
Sirloin	(9)	55.71	8.11	14.6
Trimmed full loin (6 + 9)	(11)	105.10	16.15	15.4
Flank	(60)	26.30	6.10	23.2
Kidney knob	(61)	18.12	7.62	42.0
Hanging tender	(62)	2.43	0.38	15.5
Round	(33)	155.52	21.67	13.9
Hind quarter	(64)	307.44	46.68	15.2

[a] Item numbers are integrated with those of previous publications, see footnote No. 7 of text.
[b] Figures are given in terms of pounds with the exception of slaughter grade where 5 is equivalent to "good" and 6 to "good plus" (old standard).

those in which slaughter grade is one of the variables. Two of the factors which might contribute to the cause of these high relationships are: (a) the whole-part relationship which exists wherein live weight and a basic wholesale cut are correlated and (b) the range in live weight of the animals.

[7] In this paper, the cuts are named in adherence with O.P.S. terminology in contrast to a few terms used in prior publications which were based on local terminologies. The numbering system of this paper has been integrated with those of previous papers. Identity of number indicates the same cut. Two cuts are indicated as additives of two other cuts which is in conformity with O.P.S. regulations. Fore and hind quarters and the additive cuts are listed because some workers base their results on these portions and they are presented for the convenience of comparison.

TABLE 2. ZERO ORDER CORRELATIONS (r_{xy}) AMONG WEIGHTS OF WHOLESALE CUTS AND CUTS WITH LIVE WEIGHT AND SLAUGHTER GRADE

Measurement or cut	Item No.	Item No. (1)	(2)	(19)	(55)	(57)	(58)	(26)	(59)	(6)	(9)	(11)	(60)	(61)	(62)	(33)
Live weight	(1)															
Slaughter grade	(2)	.27[a]														
Rib	(19)	.92	.26[a]													
Short plate	(55)	.91	.36	.88												
Brisket	(57)	.92	.33*	.83	.90											
Arm chuck	(58)	.93	.24[a]	.85	.83	.88										
Cross cut chuck (57 + 58)	(26)	.94	.26[a]	.87	.86	.92	.99									
Fore quarter	(59)	.97	.29*	.93	.92	.93	.98	.99								
Short loin	(6)	.89	.32*	.92	.84	.81	.86	.87	.90							
Sirloin	(9)	.92	.34*	.87	.83	.87	.91	.92	.93	.89						
Trimmed full loin (6 + 9)	(11)	.93	.34*	.92	.86	.87	.91	.92	.94	.97	.97					
Flank	(60)	.87	.44	.88	.89	.81	.79	.81	.87	.84	.81	.85				
Kidney knob	(61)	.52	.20[a]	.61	.62	.49	.36	.39	.49	.54	.41	.49	.62			
Hanging tender	(62)	.74	.19[a]	.70	.67	.71	.66	.68	.71	.64	.63	.66	.64	.47		
Round	(33)	.91	.27[a]	.87	.80	.85	.95	.95	.94	.87	.91	.91	.80	.40	.71	
Hind quarter	(64)	.95	.33*	.94	.89	.89	.92	.93	.96	.94	.94	.97	.90	.60	.73	.96

[a] Statistically non-significant correlations.
* Statistically significant at the 5 percent level. All unmarked correlations are statistically significant at the 1 percent level.

The whole-part relationships tend to inflate the size of the correlations but, as far as this study is concerned, the inflation appears to be of relatively small consequence. Correlations between weight of cut (c) and live weight minus the weight of the cut (m), where (1) — (c) = (m), were calculated for each item. The differences resulting from $r_{c(1)} - r_{cm}$ were zero for the hanging tender; 0.01 for the rib, short plate, brisket, sirloin, and flank; 0.02 for the short loin, trimmed full loin, and round; 0.03 for the cross cut chuck; 0.04 for the arm chuck, kidney knob and fore quarter; and 0.05 for the hind quarter when the zero order correlation coefficients were rounded to two decimals. Concerning the whole-part relationships within the cross cut chuck or the trimmed full loin, the correlation between the whole and one of its parts would be the correlation between the parts themselves, e.g., $r_{(9),\,(11)-(9)} = r_{(9)\,(6)}$ as (11) — (9) = (6). The differences encountered in these instances are larger than in the cases of $r_{c(1)} - r_{cm}$ but are still comparatively small.

The second factor which might have tended to make the correlations in table 2 rather high was the range in weight of the live animals as, other things being "equal," lighter weighing animals should have tended to have cuts which weighed less and *vice versa*. Using live weight as an indicator of a "size factor," first order partial correlations were calculated wherein a removal was made of the effects of variation due to live weight, table 3.

The cuts which were found to be significantly correlated in table 3 were: (a) rib with short plate, short loin, flank, and kidney knob; (b) short plate with rib, brisket, flank, and kidney knob; (c) brisket with short plate; (d) arm chuck with sirloin, kidney knob, and round; (e) short loin with rib, sirloin, flank, and round; (f) sirloin with arm chuck, short loin, and round; (g) flank with rib, short plate, short loin, and kidney knob; (h) kidney knob with rib, short plate, arm chuck, and flank; (i) round with arm chuck, short loin, and sirloin.

The hanging tender was not significantly correlated with any of the other cuts or with slaughter grade. Slaughter grade remained significantly correlated with only the short plate and flank after the effects due to variation in live weight were removed.

A reasonable degree of caution seems necessary when reviewing the results shown in table 3. Certain cuts may be expected to be correlated to some degree because of continuations of certain parts of the animal from one cut to another and/or a similarity of probable amounts of certain tissues. Within the forequarter, the rib and short plate each

TABLE 3. FIRST ORDER PARTIAL CORRELATIONS ($r_{xy.1}$) OF WEIGHTS OF WHOLESALE CUTS

Measurement or cut	Item No.	Item No. (2)	(19)	(55)	(57)	(58)	(26)	(59)	(6)	(9)	(11)	(60)	(61)	(62)	(33)
Live weight	(1)														
Slaughter grade	(2)														
Rib	(19)	.02													
Short plate	(55)	.28*	.30*												
Brisket	(57)	.20	—.06	.39**											
Arm chuck	(58)	—.03	.04	—.07	.21										
Cross cut chuck (57 + 58)	(26)	.01	.03	.01	.40**	.98**									
Fore quarter	(59)	.10	.39**	.41**	.46**	.84**	.88**								
Short loin	(6)	.18	.60**	.16	.00	.21	.20	.39**							
Sirloin	(9)	.23	.15	—.01	.20	.38**	.40**	.38**	.44**						
Trimmed full loin (6 + 9)	(11)	.24	.47**	.10	.11	.34*	.34*	.45**	.88**	.81**					
Flank	(60)	.41**	.45**	.47**	.04	—.08	—.07	.21	.31*	.06	.23				
Kidney knob	(61)	.07	.39**	.42**	.04	—.37**	—.34*	—.05	.20	—.19	.03	.41**			
Hanging tender	(62)	—.01	.09	—.01	.14	—.08	—.04	—.02	—.03	—.16	—.11	.00	.16		
Round	(33)	.04	.22	—.15	.11	.69**	.67**	.59**	.32*	.43**	.43**	.05	—.22	.14	
Hind quarter	(64)	.24	.59**	.23	.14	.37**	.37**	.56**	.70**	.51**	.73**	.51**	.41**	.13	.69**

* Statistically significant at the 5 percent level.
** Statistically significant at the 1 percent level.

possess parts of the same ribs and have some muscles in common. The short plate and the brisket have some common muscles and similar parts of the ribs. The rib, short loin, and sirloin represent, in certain aspects, segments of the same muscles and, from observation, frequently had similar amounts of fat deposited in and between some of the muscles and over the outside of the cuts.

Some of the cuts such as the round and arm chuck, and flank and rib which had no apparent continuity of structure were, however, significantly correlated. From a developmental standpoint, it seems logical that the round and arm chuck could be significantly correlated.

As slaughter grade is a customary estimate made in studies of this nature and the question of the effects of slaughter grade arises in discussions of the yield and weights of cuts, second order partial correlations removing the effects due to association of both live weight and slaughter grade were calculated and presented in table 4. It should be kept in mind that slaughter grade is determined by several factors: conformation, quality, relative amount of condition, and smoothness of finish. As the use of a one figure index for slaughter grade includes the four items and each item plays a varying degree of importance in the estimation of slaughter grade for each animal, it cannot be clearly determined just what factors are removed in partial correlations of this nature.

Discussion

The difference in size of correlations of the same items in tables 3 and 4 are not great. In a number of cases the figures are identical. Most of the others vary by less than three or four one-hundredths. The correlation between the short plate and flank in table 4 is 0.07 lower than in table 3. The correlation between the short loin and flank is statistically significant in table 3 but not in table 4; the difference in absolute magnitude is but 0.05. These differences and the situation of slaughter grade being correlated to only a small degree with most of the cuts, table 3, may be due to the relatively small variation in slaughter grade. The standard deviation of item (2), table 1, is only a little over one-third of a grade unit wherein the difference between "good" and "choice" is defined as a grade unit.

Slaughter grade was significantly correlated, table 3, with the short plate and flank which involve the lower part of the posterior segment of the thoracic and the lower part of the abdominal cavities respectively. Whether or not these associations reflect conformational differences—

TABLE 4. SECOND ORDER PARTIAL CORRELATIONS ($r_{xy.1,2}$) OF WEIGHTS OF WHOLESALE CUTS

Measurement or cut	Item No.	Item No. (19)	(55)	(57)	(58)	(26)	(59)	(6)	(9)	(11)	(60)	(61)	(62)	(33)
Live weight	(1)													
Slaughter grade	(2)													
Rib	(19)													
Short plate	(55)	.31*												
Brisket	(57)	—.06	.35*											
Arm chuck	(58)	.04	—.06	.22										
Cross cut chuck (57 + 58)	(26)	.03	.01	.41**	.98**									
Fore quarter	(59)	.39**	.40**	.45**	.85**	.88**								
Short loin	(6)	.60**	.11	—.04	.22	.20	.38**							
Sirloin	(9)	.15	—.08	.16	.40**	.41**	.37**	.41**						
Trimmed full loin (6 + 9)	(11)	.48**	.03	.06	.36*	.35*	.44**	.88**	.80**					
Flank	(60)	.48**	.40**	—.05	—.08	—.08	.18	.26	—.04	.15				
Kidney knob	(61)	.39**	.42**	.03	—.37**	—.34*	—.06	.20	—.21	.02	.42**			
Hanging tender	(62)	.09	—.01	.15	—.08	—.04	—.01	—.03	—.17	—.11	.01	.16		
Round	(33)	.22	—.17	.10	.69**	.67**	.59**	.32*	.43**	.44**	.03	.21	.14	
Hind quarter	(64)	.60**	.18	.09	.39**	.38**	.55**	.69**	.49**	.71**	.46**	.41**	.14	.70**

* Statistically significant at the 5 percent level.
** Statistically significant at the 1 percent level.

depth of body for example—or differences in the amount of fat deposited, or both, cannot be determined from these data. In future studies of this nature, it would probably be best to score each factor of slaughter grade separately.

The highest correlation between cuts not having structural continuity was that of the round and arm chuck, 0.69, (table 3). The magnitudes of the correlations of these two cuts with slaughter grade were quite similar in tables 2 and 3. This along with observations made on the carcasses, indicated that the type of tissue contributing most to the variations in weights of these two cuts was, apparently, muscle. In this study as well as in previous ones (White and Green, 1952 and Green, 1954), various measures of "largeness" and "muscle" appear to be associated concerning the regions of the shoulder and round.

For purposes of selection, the correlation of 0.69 indicates a fair degree of predictability from one part to the other. Most of the other correlations among cuts not having structural continuity or divisions of essentially the same bones, muscles, etc., were in the range of 0.35 to 0.45. The value of correlations of this size in terms of satisfactory predictability of one item from the other depends, of course, on their ultimate use. In terms of searching for reliable predictor variables in connection with selection, it appears that it might be best to treat each cut by itself and to exercise caution in estimating the weight of one cut from a visual and/or manual estimate of another. As indicated in the previous papers of this study, a rather reliable estimate of the weights of the cuts seems to be obtainable by use of measurements taken on the live animal. Although the weights of the kidney knob and flank were found to be correlated with a number of cuts (table 3), the kidney knob is, of course, useless as a measure during visual evaluation of live animals as it is unobservable. According to usual teachings, fat is supposed to be deposited in those areas at a disproportionate rate with an increase in the general degree of condition of the animal. In judging, especially in the classroom, the amount of fat deposited in the skin-fold of the rear flank is frequently used as an indicator of condition. The main problem which arises in judging livestock is that the wholesale cut called the flank is not easily observed in the live animal and it is almost a separate entity from that portion of the rear flank region which is so commonly used as an indicator of the degree of fatness in the live animal. The "rear flank" of the live animal, as seen or handled, is composed primarily of a fold of skin and a relatively small (in terms of pounds) deposit of fat. The skin is removed during slaughter and

the fat remains on the carcass as a relatively small amount of weight attached to the abdominal wall of which the wholesale cut, the flank, is primarily composed. The correlation between the size of the fat deposition in the rear flank, as handled, and the weight or fatness of the wholesale cut of the flank was not determined in this study nor have the authors been able to find published data concerning the degree of association between those parts. In view of the results of this study, it appears that it might be profitable to investigate the rate of deposition of fat in the body wall area of the flank not only in regard to the rest of the carcass but also in connection with the time and rate of deposition of fat in the skin-fold portion of the flank.

Summary

Relationships among the weights of the wholesale cuts, live weight, and slaughter grade were studied from data secured from 50 steers and their carcasses. Zero order correlations as well as first order partial correlations removing the effects due to variation in live weight and second order partial correlations removing effects due to variations in live weight and slaughter grade were presented. Little effect was produced on the correlations between live weight and wholesale cuts because of the involvement of a whole-part relationship. The slight effect of slaughter grade on the size of correlations between cuts was probably due to the relatively small amount of variation in grade. A number of cuts were found to be statistically significantly correlated, among them some structurally independent cuts. For most of the latter, the first order partial correlations were in the range of 0.35 to 0.45 while the round and arm chuck were correlated to the extent of 0.69.

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SACCHARIN AND DRIED CANE MOLASSES IN SWINE RATIONS

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SWEETENING agents are being used in practical swine rations in an attempt to increase feed consumption and hence the level of performance, particularly of the suckling pig.

At the Illinois Station, Terrill *et al.* (1952) reported that the addition of a dried molasses product to rolled oats or dried skim milk improved their palatability for the suckling pig. Lewis *et al.* (1953) noted that 20 percent cane sugar mixed into a pelleted pig starter appeared to enhance its acceptability, although the same amount of cane sugar applied as an exterior coating to the pellets seemed to decrease the palatability of the starter. Neither of the above studies was designed to measure the effect of the sweetening agent upon the rate and efficiency of gains in the pigs.

Recently, Scott (1953) published a review on the nutritive value of molasses in animal feeding. Evidence of its value obtained with swine is apparently more conflicting than that obtained with the other species of farm animals. However, the reviewer feels that if attention is given to the nutritional balance of the ration the use of molasses as a swine feed will produce economical performance.

In regard to saccharin in swine rations, Jagoda (1927) reported that saccharin additions stimulated an increased feed consumption and rate of gain. On the other hand, with beet molasses he noted an increased feed consumption for the first 28 days after which the feed intake was depressed.

The objective of the study reported here was to determine the value of saccharin and dried cane molasses as additives to swine rations.

Experimental

Four experiments were conducted with growing-fattening pigs fed in drylot.

The mixed rations employed in Experiment 1 are outlined in table 1.

[1] The authors wish to acknowledge Monsanto Chemical Company, St. Louis 1, Missouri, and Central Soya Co., Inc., Fort Wayne, Indiana, for funds and products which made this investigation possible.

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TABLE 1. COMPOSITION OF THE MIXED RATIONS FED IN EXPERIMENT 1

Ration designation	A	B
	(pounds)	
Ground yellow corn	80.0	73.0
Soybean oil meal	12.0	11.8
Dried cane molasses [a]	....	7.2
Menhaden fish meal	1.0	1.0
Meat and bone scrap	3.0	3.0
Dehydrated alfalfa meal	2.0	2.0
Antibiotic-vitamin B_{12} supplement [b]	0.5	0.5
Vitamin supplement [c]	0.05	0.05
Vitamin A and D supplement (4000A, 750D)	0.1	0.1
Mineral mixture [d]	1.5	1.5

[a] Added as a commercial product in which cane molasses is dried on soybean oil meal so as to yield 38 percent molasses in the mixture. Manufactured by Central Soya Co., Inc., Fort Wayne, Indiana.

[b] Guaranteed to contain 1.8 gm. of chlortetracycline HCl and 1.8 mg. of vitamin B_{12} per pound.

[c] Guaranteed to contain 2 gm. of riboflavin, 4 gm. of pantothenic acid, 9 gm. of nicotinic acid, and 90 gm. of choline chloride per pound.

[d] Equal parts of steamed bone meal, ground limestone and trace-mineralized salt (NaCl).

Thirty weanling Yorkshire and Yorkshire × Hampshire pigs were allotted at random to the treatments from outcome groups of five pigs each. Outcome groups were formed on the basis of weight, ancestry,

TABLE 2. PERFORMANCE OF PIGS FED SACCHARIN AND DRIED CANE MOLASSES

Treatment	No. of pigs	Av. initial wt.	Av. daily gain	Feed per lb. gain, lb.		
				Corn	Supplement	Total
		lb.	lb.			
Experiment I						
Lot 1—Ration A	6	39	1.62	....	....	2.92
Lot 2—Ration A + 0.03% saccharin	6	38	1.50	....	....	2.91
Lot 3—Ration A + 0.10% saccharin	6	39	1.55	....	....	2.83
Lot 4—Ration B	6	40	1.45	....	....	3.04
Lot 5—Ration B + 0.03% saccharin	6	39	1.53	....	....	3.02
Experiment II						
Lot 1—Ground corn	6	90	1.11	3.88	0.44	4.32
Lot 2—Ground corn + 0.1% saccharin	6	90	1.14	3.90	0.49	4.39
Lot 3—Shelled corn	6	93	0.93	4.03	0.48	4.51
Lot 4—Shelled corn + 0.1% saccharin	6	93	1.08	3.94	0.44	4.39
Experiment III						
Lot 1—Shelled corn	6	47	0.98	2.76	0.93	3.69
Lot 2—Shelled corn + 0.05% saccharin	6	44	1.00	2.68	0.93	3.61
Lot 3—Shelled corn	6	47	1.02	2.60	1.17	3.77
Lot 4—Shelled corn + 0.10% saccharin	6	43	1.12	2.37	0.95	3.32

and condition. Treatments were assigned to the pens at random. The pigs were self-fed *ad libitum* in treatment groups for a period of 8 weeks. Recommended management practices were followed. The treatments are presented in table 2.

Twenty-four Hampshire pigs were used in each of Experiments 2 and 3. The pigs were allotted at random to the treatments from outcome groups made up on the basis of weight and condition. The feeds were self-fed *ad libitum* in treatment groups for a period of 4 weeks in Experiment 2, and 8 weeks in Experiment 3. In both studies, a supplement was fed which consisted of 23 percent meat scrap (55 percent), 24.1 percent soybean oil meal, 22.5 percent alfalfa meal, 23 percent dried corn distillers' solubles, 4 percent steamed bone meal, 2 percent trace-mineralized salt, 1.1 percent antibiotic-vitamin B_{12} supplement,* and 0.3 percent vitamin supplement.* Saccharin (Sodium, soluble, U.S.P. powder) was mixed with ground corn in a feed mixer; whereas, with shelled corn it was added as a solution and mixed manually.

In Experiment 4 six pairs of Hampshire pigs were divided at random into two groups. Each group was given access *ad libitum* to shelled corn, shelled corn plus 0.05 percent saccharin, and supplement. The supplement was the same as described previously. Each feed was kept in a separate feeder, and the feeders were switched daily in order to equalize positional effects. Pig weights and feed consumption were recorded at biweekly intervals.

Results and Discussion

The statistical analysis of daily gains in Experiment 1 indicated that the differences were not significant. Saccharin at either 0.03 or 0.10 percent of ration A had no effect on rate of gain, feed intake or efficiency of feed utilization. Likewise, 0.03 percent saccharin with ration B had no effect on performance. The rate and efficiency of gain were satisfactory for pigs fed ration B which contained 7.2 percent dried cane molasses. There was no indication of diarrhea among the pigs fed molasses.

The analysis of variance for Experiments 2 and 3 failed to reveal significant differences in daily gains. For the pigs at an initial weight of approximately 90 lb., ground corn was equal to shelled corn when fed with the supplement. The addition of 0.1 percent saccharin failed to affect rate or efficiency of gain. Likewise, with the smaller pigs in Experiment 3, neither 0.05 nor 0.10 percent saccharin influenced performance.

* See footnotes b and c in table 1.

The results of Experiment 4 are presented in table 3. During the first 27 days of the test the pigs tended to select greater quantities of the corn treated with 0.05 percent saccharin than of the regular corn. Actually, during the first 13 days, 64.2 and 63.4 percent of the total corn consumed was the saccharin-treated corn in group 1 and 2, respectively. On the other hand, during the last 14 days of the trial, approximately equal quantities of the two types of corn were selected.

As sweetening agents, dried cane molasses and saccharin apparently have no value for increasing feed intake, and hence rate of gain, in the growing-fattening pig. However, dried cane molasses may be used

TABLE 3. EFFECT OF SACCHARIN ON THE PALATIBILITY OF SHELLED CORN AS MEASURED BY SELF-SELECTION

Group No.	1			2		
No. of pigs	6			6		
Av. initial wt., lb.	54			53		
Av. daily gain, lb.	1.26			1.11		
Feed per lb. gain, lb.	3.22			3.58		
Av. daily feed per pig, lb.	4.06			3.98		
	Shelled corn	Shelled corn + saccharine	Supplement	Shelled corn	Shelled corn + saccharin	Supplement
Initial to 13 days	0.72	1.29	0.77	0.78	1.35	0.55
14 to 27 days	0.76	1.39	1.36	1.15	1.32	1.05
28 to 41 days	1.63	1.43	1.55	1.56	1.75	1.46
42 to 55 days	1.79	1.88	1.60	1.85	1.63	1.39
Total period	1.23	1.50	1.33	1.34	1.52	1.12

as a source of energy and as such it may be fed at a rate of 7.2 percent of the ration without deleterious effects. Our observations with saccharin do not agree with the results reported by Jagoda (1927). However, Jensen *et al.* (1954) observed that saccharin at a 0.5 percent level did not result in a significant improvement in the palatability of a supplementary ration for the suckling pig.

Summary

The value of saccharin and dried cane molasses in swine rations was investigated.

When added to a practical mixed ration for the weanling pig, saccharin at a rate of 0.03 or 0.10 percent or dried cane molasses fed at a rate of 7.2 percent failed to exert a significant effect on feed consumption, rate of gain, or feed efficiency.

The addition of 0.1 percent saccharin to ground or shelled corn which was self-fed, free choice, with a supplement, also failed to affect performance. In a palatability trial, however, pigs showed a preference for shelled corn treated with 0.05 percent saccharin during the first half of a 55-day feeding period. No marked preference was noted during the latter half of the study.

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A COMPARISON OF PHOSPHORUS FROM DIFFERENT SOURCES FOR GROWING AND FINISHING SWINE

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NUMEROUS investigators have reported that additions of steamed bone meal, superphosphates, sodium and calcium phosphates and rock phosphates to practical swine rations often resulted in improved daily gains and in some cases prevented bone abnormalities from developing; Forbes (1909, 1909a); Burnett (1906, 1908, 1910); Robison (1926); Shrewsbury and Vestal (1945) and Mitchell *et al.* (1937).

While Forbes (1914) reported slower daily gains and poorer feed efficiency when phytin phosphorus was fed to pigs, compared with various other phosphate sources, Hart *et al.* (1909) concluded that the pig was able to utilize phytin phosphorus. Other investigations with rats, chickens and dogs have shown that species may differ in their ability to utilize phosphorus from plant sources (phytin phosphorus); Boutwell *et al.* (1946), Spitzer and Phillips (1945); Gillis *et al.* (1953); Singsen and Mitchell (1944) and Mellanby (1949).

The accumulation of soft phosphate with colloidal clay, the residual by-product of the rock phosphate mining industry of North Central Florida, has resulted in a large potential source of phosphorus for feed and fertilizer use. Considerable interest has developed in the use of this material as a phosphorus supplement for poultry. Miller and Joukovsky (1953), Grau and Zweigert (1953) and Gillis *et al.* (1954), using growth response and bone calcification in poultry as criteria, reported that the biological value of the soft phosphate with colloidal clay was not equal to that of dicalcium phosphate or steamed bone

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meal. Gobble and Miller (1953), and Gobble *et al.* (1954) observed no significant differences in rate of gain, feed efficiency, blood serum inorganic phosphorus and percent of ash or phosphorus in the moisture-free bone between groups of swine fed dicalcium phosphate and those fed colloidal clay. They also reported that gross symptoms of fluorosis were not observed.

In view of the dearth of both qualitative and quantitative data concerning the comparative nutritional value of phosphorus from plant, animal and mineral sources for swine, it seemed desirable to further investigate this general problem.

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

	Source of phosphorus								
	Plant phosphorus			Steamed bonemeal		Soft phosphate with colloidal clay		Dicalcium phosphate	
P from supplement (%)	0.00	0.15	0.30	0.18	0.30	0.18	0.30	0.18	0.30
P from plant source (%)	0.50	0.35	0.20	0.32	0.20	0.32	0.20	0.32	0.20
(Ingredients)									
Wheat bran	19.00	4.00	.....	.....	.....	.....	.....	.....	.....
Gr. yellow corn	60.85	67.55	.....	75.40	.....	74.40	.....	75.60	.....
Brewers' grits	.....	.....	61.75	.....	69.95	.....	68.95	.....	70.95
Oat hulls	.....	3.50	8.00	.....	.....	.....	.....	.....	.....
Corn oil (crude)	.....	0.40	2.65	.....	2.40	.....	2.40	.....	2.40
Solv. soybean oil meal	16.00	20.20	23.00	20.00	22.50	20.30	21.50	20.00	22.00
Trace minerals [a]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt (iodized)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Calcium carbonate	1.55	0.95	0.35	0.50	.....	0.55	.....	0.85	0.40
Phosphorus-carrier	.....	0.80	1.65	1.50	2.55	2.15	3.55	0.95	1.65
Vitamin premix [b]	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Contributed the following ppm. to the ration: Fe, 70; Co, 1.6; Cu, 4.8; Mn, 59; Zn, 4.4 and K, 76.

[b] Contributed the following per pound of total ration: a-Tocopherol, 1.0 mg.; biotin, 0.1 mg.; calcium pantothenate, 6.0 mg.; choline chloride, 250.0 mg.; folic acid, 0.5 mg.; menadione, 0.5 mg.; niacin, 20.0 mg.; pyridoxine HCl, 1.5 mg.; riboflavin, 1.5 mg.; thiamine HCl, 1.5 mg.; vitamin A, 300 I.U; vitamin D_2, 200 IU.; and vitamin B_{12}, 5.0 mcg.

Experimental

The randomized block design experiment consisted of two replications. As shown in table 1, there were nine phosphorus treatments. These were fed with and without chlortetracycline (Aureomycin HCl) for a total of eighteen ration treatments, or lots, per replication. Two barrow and two female pigs were placed in each lot with a total of 144 weanling pigs of Poland China $\times$ Landrace $\times$ Duroc breeding being used. The ration treatments were allotted at random to the pens within the replications, and the pigs were allotted at random to the treatments

by weight outcome groups within sex, within replication. Prior to placement on the experimental rations, all pigs were wormed with sodium fluoride, sprayed with benzene hexachloride and dipped in lime sulfur. They were confined indoors on concrete and bedded with wood shavings. The pens were cleaned daily. Each pig was removed from the experiment when it reached a liveweight of 200 lb. Water and feed were given *ad libitum*. Body weights and feed consumption were determined bi-weekly.

The experimental rations are presented in table 1. The rations were formulated so that each had the same calcium and phosphorus level and ratio. The percentages of calcium and phosphorus used in the experimental rations were 0.7 and 0.5, respectively, since Roberts (1953) reported that these levels appeared to give best results with antibiotic-supplemented growing rations. To eliminate possible effect due to the method of production of the commercial phosphorus supplements, the various types of phosphorus-containing materials were obtained from three different producers and equal parts of these were then thoroughly blended before incorporation into the experimental rations. Each phosphate supplement was tested at two different levels. The percent of each phosphorus supplement needed to supply these levels is shown in table 1. Wheat bran was used to increase the plant phosphorus for testing the availability of phytin phosphorus. Constant fiber levels were maintained by adding oat hulls. In determining the ability of the pig to utilize phosphorus from plant source (phytin phosphorus) dicalcium phosphate was arbitrarily chosen as the inorganic phosphate supplement for comparison.

The protein level of the experimental rations was maintained at 16 percent throughout the entire experiment. A vitamin premix was included in the rations (table 1).

Blood samples were taken from each animal at 100 and 200 lb. in weight. Duplicate organic, inorganic and total serum phosphate determinations were made using the procedure of Zilversmit and Davis (1950).

One animal of each sex from each pen was chosen by pre-experimental randomized selection for slaughter when it reached a live weight of 200 lb. Both femurs of each of these carcasses were analyzed for phosphorus and ash content. The phosphorus content was determined by the procedure of Fiske and Subbarow (1925). Breaking strength of the femurs was determined by the method described by Roberts (1953). Fluorine determinations on the feed and samples of bone were made by a commercial laboratory.

TABLE 2. SUMMARY OF MEAN SQUARES FROM THE ANALYSES OF VARIANCE OF GROWTH, FEED AND BONE DATA

Source of variation	Degrees of freedom	First 8 week period [a]			25 to 200 lb.[a]			Femur measurements [b]		
		Daily gain	Daily feed	Feed/ gain	Daily gain	Daily feed	Feed/ gain	Break strength	% ash	% P in ash
Replication	1	.....	.....	...	.....	.....	....	.....	.....	.....
All treatments	17	0.0212*	0.1424	613	0.0195*	0.2405	1339*	25366	2.184	0.1825
Plant P vs. suppl. P	1	0.0561*	0.1702	292	0.0071	0.6290	4917*	11467	0.004	0.3120
Among plant P	5	0.0318*	1.3315	672	0.0166*	0.1148	1282*	13578	1.611	0.1688
Levels inorg. P	2	0.0675*	0.4684*	796	0.0339*	0.1630	3139*	13743	2.725	0.0950
Linear component	1	0.1200*	0.3321	666	0.0648*	0.1225	6050*	13340	4.516	0.1220
Quadratic component	1	0.0150	0.6048*	925	0.0030	0.2035	228	14145	0.935	0.0680
Antibiotic	1	0.0075	0.2670	456	0.0088	0.1776	40	26334	0.602	0.5100
Levels P × Ab	2	0.0082	0.0638	656	0.0033	0.0352	46	7034	1.000	0.0720
Treatment among P suppl.	11	0.0132	0.0835	616	0.0219*	0.2623*	1039*	31988	2.643	0.1771
Among P suppl.	2	0.0548*	0.1173	458	0.0914*	0.2804*	802*	110600*	5.296*	0.1690
BM vs. Dical + CC	1	0.0380*	0.0184	683	0.0651*	0.1018	901*	134775*	0.128	0.0376
Dical vs. CC	1	0.0716*	0.2162	233	0.1177*	0.4590	702	86424	10.465*	0.3003
Levels inorg. P	1	0.0001	0.4988*	2667	0.0000	1.9551	7957*	315	2.125	0.1300
Antibiotic	1	0.0070	0.0400	1	0.0257*	0.0273	495	25254	0.130	0.8270
Suppl. × levels P	2	0.0105	0.0348	464	0.0122	0.0768	8	12328	3.996	0.1205
Suppl. × Ab	2	0.0010	0.0158	130	0.0003	0.0812	484	9092	0.008	0.1020
Levels P × Ab	1	0.0012	0.0113	155	0.0004	0.0247	26	1271	0.152	0.0920
Suppl. × level P × Ab	2	0.0020	0.0162	926	0.0037	0.0008	185	30498	4.032	0.0580
Expt. error (a)	17	0.0072	0.1011	486	0.0048	0.0541	172	19522	1.113	0.2961
Sex	1	.....	.....	....	.....	.....	....	58140	7.157	0.8450
Sex × all treatments	17	.....	.....	....	.....	.....	....	7635	2.302	0.0521
Expt. error (b)	17 [c]	.....	.....	....	.....	.....	....	18519	3.294	0.2700
All causes	70 [c]	.....	.....	....	.....	.....	....	.....	.....	.....

[a] Analyses of variance performed using the pen of 4 pigs as the experimental unit.
[b] Analyses of variance performed using 2 pigs, of different sex, from the same pen as the experimental unit.
[c] One degree of freedom used for estimated value.
* Treatment effects significant at P = 0.05 or less.

The data were analyzed statistically according to the plans in table 2. All stated levels of statistical significance are at $P = 0.05$ or less. The statistical analysis of the several measurements studied has been carried out in the main in two parts; (1) among levels of plant phosphorus and, (2) among the three phosphorus supplements, namely: steamed bone meal, colloidal clay and dicalcium phosphate. The average effect over the whole experiment has been considered, however, in the case of antibiotic, sex, and weight influence.

TABLE 3. SUMMARY OF AVERAGES FOR DAILY GAIN, DAILY FEED CONSUMPTION AND FEED PER LB. GAIN FOR FIRST 8 WEEK AND 25 TO 200 LB. PERIODS

Kation treatment	No. Pigs	1st 8 week period			25 to 200 lb. period		
		Av. daily gain	Av. daily feed	Av. feed/lb. gain	Av. daily gain	Av. daily feed	Av. feed/lb. gain
		lb.	lb.	lb.	lb.	lb.	lb.
No chlortetracycline	72	1.37	3.5	2.59	1.54	5.0	3.27
Chlortetracycline, 5 mg.	72	1.41	3.7	2.63	1.60 [b]	5.1	3.22
Steamed bonemeal							
Inorg. P *Plant P*							
0.18 [a] 0.32	16	1.43	3.8	2.66	1.64	5.3	3.26
0.30 0.20	16	1.51	3.6	2.37	1.66	4.8	2.90
Av.	32	1.47	3.7	2.52	1.65	5.0	3.08
Dicalcium phosphate							
Inorg. P *Plant P*							
0.18 0.32	16	1.48	3.9	2.61	1.59	5.3	3.34
0.30 0.20	16	1.42	3.7	2.58	1.66	4.9	2.95
Av.	32	1.46	3.8	2.59	1.63	5.1	3.14
Colloidal clay							
Inorg. P *Plant P*							
0.18 0.32	16	1.33	3.8	2.82	1.50	5.2	3.45
0.30 0.20	16	1.31	3.3	2.52	1.42	4.4	3.10
Av.	32	1.32 [c]	3.5	2.67	1.46 [c]	4.8 [c]	3.28 [c]
Inorg. P *Plant P*							
0.18 0.32	48	1.41	3.8	2.70	1.58	5.3	3.35
0.30 0.20	48	1.42	3.5 [d]	2.49 [d]	1.58	4.7 [d]	2.98 [d]
Levels of plant P sources							
0.50	16	1.18 [d]	3.1 [e]	2.68	1.45 [d]	5.3	3.66 [d]
0.35	16	1.38	3.8	2.78	1.57	5.4	3.48
0.20	16	1.43	3.6	2.50	1.63	5.0	3.11

[a] Values are percent of total ration.
[b] Average effect of antibiotic significant at $P = 0.05$ or less.
[c] Average effect of source of phosphorus significant at $P = 0.05$ or less.
[d] Linear effect of level of inorganic phosphorus significant at $P = 0.05$ or less.
[e] Quadratic effect of level of phosphorus from plant sources significant at $P = 0.05$ or less.

Results

First 8 Week Period

While some additional response was obtained from the inclusion of chlortetracycline in the ration, the data (table 3) show no significant

difference in the rate of gain, average daily feed intake or feed efficiency.

The source of phosphorus supplement had no significant effect on either average daily feed intake or feed efficiency; however, the average daily gain was significantly reduced in those pigs receiving colloidal clay compared with those fed steamed bonemeal or dicalcium phosphate (table 3). Pigs receiving the higher levels of phosphorus from the inorganic phosphorus supplements ate significantly less feed per day and required significantly less feed per pound of gain than those receiving more of their phosphorus from plant sources.

As the level of phosphorus from an inorganic source (dicalcium phosphate) was increased from 0.0 to 0.3 percent of the total ration (table 3), there was a significant linear effect of the inorganic phosphorus on increasing rate of gain and a significant quadratic effect on increasing average daily feed intake. However, there was no significant effect upon feed efficiency as the percent of phosphorus from plant sources decreased.

Analyses of blood serum for inorganic phosphorus were made when animals reached 100 lb. in weight. Considerable hemolysis occurred in all blood samples. The effects of hemolysis on the results of these analyses were not evaluated. No significant effect of ration treatments on the blood data was discernible during this period and therefore the individual data are not shown.

Period from 25–200 lb.

In contrast to the results of the first 8 week growth period, there was, as shown in table 3, a small but significant increase in average daily gains when chlortetracycline was included in the rations. The differences in feed intake and feed efficiency resulting from antibiotic feeding were extremely small.

The pigs receiving colloidal clay gained significantly slower than those receiving either steamed bonemeal or dicalcium phosphate, but there was little difference in the rates of gain between pigs receiving the latter two supplements. The daily feed intake of the pigs fed colloidal clay was significantly less than for the pigs fed dicalcium phosphate. The difference in the feed intake between the colloidal clay and the bonemeal group was just short of significance at $P = 0.05$.

The feed efficiency of the pigs receiving colloidal clay was significantly poorer than those fed steamed bonemeal, but not quite significantly poorer when compared with that of the pigs receiving dicalcium phosphate.

When the average level of phosphorus, furnished in the ration by the

three supplements, was increased from 0.18 to 0.30 percent there was no effect on the rate of gain; however, the amount of feed required per pound of gain and the average daily feed intake were significantly decreased.

TABLE 4. SUMMARY OF AVERAGES FOR BREAKING STRENGTH, ASH CONTENT AND PHOSPHORUS CONTENT OF FEMURS

Ration treatment			No. pigs	Breaking strength	Ash content of femurs	P content of femur ash
				lb./sq. in.	%	%
No chlortetracycline			36	1255	57.5	18.9[b]
Chlortetracycline, 5 mg.			36	1247	57.5	18.6
Steamed bonemeal						
Inorganic P	*Plant P*					
0.18[a]	0.32		8	1304	56.9	18.7
0.30	0.20		8	1366	58.5	18.9
		Av.	16	1335[c]	57.7	18.8
Dicalcium phosphate						
Inorganic P	*Plant P*					
0.18	0.32		8	1299	57.1	19.0
0.30	0.20		8	1250	56.9	18.9
		Av.	16	1274	57.0	18.9
Colloidal clay						
Inorganic P	*Plant P*					
0.18	0.32		8	1170	58.2	18.7
0.30	0.20		8	1172	58.1	18.8
		Av.	16	1171	58.2[c]	18.8
Inorganic P	*Plant P*					
0.18	0.32		24	1248	57.4	18.8
0.30	0.20		24	1263	57.8	18.9
Levels of plant P						
0.50			8	1187	57.2	18.8
0.35			8	1268	57.4	18.6
0.20			8	1245	58.3	18.6
Sex						
Barrows				1223	57.3	18.7
Sows				1280	57.9	18.9

[a] Percent of total ration.
[b] Average effect of antibiotic significant at $P = 0.05$ or less.
[c] Effect of sources of phosphorus significant at $P = 0.05$ or less.

Increasing the proportion of inorganic phosphorus in the rations resulted in a significant linear increase in daily gain and improvement in feed efficiency for the pigs fed these rations.

As shown in table 4, the breaking strength of the femurs of the pigs

receiving steamed bonemeal was significantly higher than the average breaking strength of the femurs from the pigs receiving either colloidal clay or dicalcium phosphate.

There was no significant difference in the phosphorus content of the femurs resulting from any of the experimental phosphorus treatments. However, there was a significantly higher phosphorus content in the femurs from pigs receiving no antibiotic, as compared with those from pigs receiving chlortetracycline.

There was a significant increase in the ash content of the femurs from the pigs receiving colloidal clay as compared with the pigs fed the other phosphorus supplements. There were some weight changes

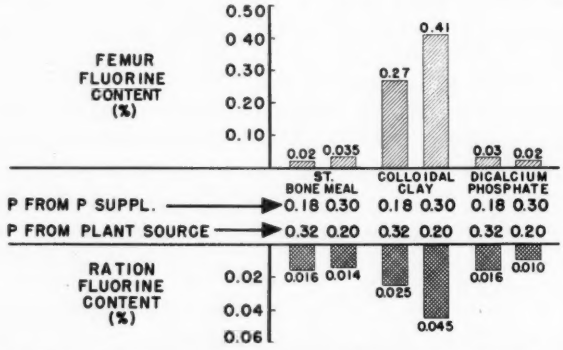

Figure 1. Fluorine content of experimental rations and femurs from pigs receiving phosphorus supplements.

observed in the bone marrow from the femurs of the pigs receiving colloidal clay. The total weight of fresh bone marrow from these bones was lower on the average than from the bones of the pigs receiving the other phosphorus supplements. Marrow calcification in the anterior and posterior portions of the medullary cavity was also apparent.

The effect of the three supplements upon the fluorine content of the femurs is shown in figure 1. As the fluorine content of the rations increased, there was a corresponding increase in the fluorine content of the femur bones. The fluorine content of the rations and the femurs of the pigs fed steamed bonemeal and dicalcium phosphate were similar. However, supplementation of the ration with colloidal clay increased the fluorine content of both the rations and the femurs of the pigs fed these rations.

A significant linear increase in inorganic serum phosphorus was ob-

served as the amount of phosphorus from plant sources was decreased from 0.5 to 0.2 percent of the total ration and replaced by an equivalent amount of phosphorus from dicalcium phosphate. There was also a significant decrease of serum inorganic phosphate due to age. There was no other significant effect of ration treatment on serum inorganic phosphorus. As stated previously, due to the inability to adequately evaluate the effect of the hemolysis, these data are not presented.

Discussion

The performance of the pigs on the all-plant phosphorus rations was progressively improved as the content of phosphorus from plant sources was decreased and replaced by an equivalent amount of phosphorus from dicalcium phosphate. This is presented graphically in figure 2.

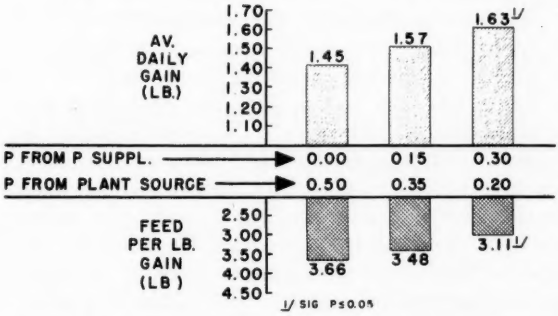

Figure 2. Levels of plant vs. inorganic phosphorus. Summary of av. daily gain and feed/lb. gain (25–200 lb.)

However, it is emphasized that such alteration in the proportionate amounts contributed from the two kinds of phosphorus had no significant effect on ash or phosphorus content of the bone, or on breaking strength of the femurs. In earlier studies Hart *et al.* (1909) reported that wheat bran could serve as the main source of dietary phosphorus for the skeletal development of growing swine, while Forbes (1914) compared phytin phosphorus to inorganic phosphorus and reported decreased rate of gain, feed efficiency and femur ash when the phytin phosphorus was the only source. The current studies are in partial agreement with the latter in that there was a significantly decreased rate of gain and feed efficiency when the phosphorus was supplied entirely by plant sources. When the same levels of phosphorus from the different phosphorus supplements was fed, no significant corre-

lation between blood serum inorganic phosphorus and experimental ration treatments could be demonstrated. This is in agreement with Bohstedt *et al.* (1926). However, there was a significant linear increase in the serum inorganic phosphorus levels when the proportion of inorganic phosphorus to plant phosphorus was increased. These results show that the pig cannot utilize phosphorus from plant sources as well as that from dicalcium phosphate.

Roberts (1953) suggests that for a margin of safety, phosphorus levels slightly in excess of those recommended by the National Research Council be used in growing-finishing swine rations which contain chlortetracycline. It has been reported by Lindblad *et al.* (1952) that chlortetracycline enhanced phosphorus utilization in poultry and prevented bone abnormalities in chicks (Pepper *et al.*, 1952). Since chlortetracycline did produce a lower average for breaking strength and for percent of phosphorus in the femur, it is possible that chlortetracycline did have an effect upon phosphorus metabolism in the bone. The differences are not of sufficient magnitude to be considered conclusive, however. Chlortetracycline had no significant effect upon bone ash or phosphorus content of blood serum of the growing-finishing pig.

The responses of the pigs in this experiment were essentially the same when bonemeal or dicalcium phosphate provided all of the supplemental phosphorus in their rations as measured by daily gain, daily feed and feed per 100 lb. gain. This is in agreement with Mitchell *et al.* (1937). The results of feeding the three different kinds of phosphate supplements to the pigs were in agreement with Gobble and Miller (1953) and Gobble *et al.* (1954) for phosphorus content of bone ash. However, these workers reported no significant effect on the rate of gain, feed efficiency or femur bone ash content when colloidal phosphate was fed. In the research reported herein, there was a significant decrease in rate of gain, feed efficiency and breaking strength of femurs along with a significant increase in femur ash content when colloidal clay was compared with dicalcium phosphate or steamed bonemeal. Source of phosphorus supplement had no significant effect on blood serum phosphate.

In the absence of significant differences in femur phosphorus content and in the presence of a many-fold increase in fluorine content of the femurs, accompanied by the apparent excessive calcification of the matrix in the posterior and anterior portions of the medullary cavity of the femurs of swine receiving the colloidal clay, it is suggested that the decreased breaking strength and increased ash content may be the result of structural or physical changes in the crystals of hydroxylapatite

or bone mineral. Mitchell and Edman (1952) in their review state that the growing pig can tolerate 0.014 percent fluorine from rock phosphate in the dry matter consumed. As seen in figure 1 the average fluorine in the ration, for the two levels of colloidal clay fed, were 0.025 and 0.045 percent, respectively. In view of these considerations a potential fluorine toxicological hazard is in the realm of possibility. One may suggest that if colloidal clay is to be used as a phosphate source for the pig, that consideration be given to the question of what constitutes the maximum amount that may be safely added to growing-finishing swine rations. It is not possible to supplement a swine ration that is highly deficient in phosphorus by the use of soft phosphate with colloidal clay only, without exceeding the AOAC maximum fluorine tolerance which is 0.014 percent of the total ration.

Summary and Conclusions

Two replicates of 18 pens of 4 pigs each (total 144 pigs) were fed in concrete drylot to determine: (1) the relative value of soft phosphate with colloidal clay, dicalcium phosphate and steamed bonemeal as inorganic phosphorus supplements for growing-finishing swine, (2) the effect of including these inorganic supplements at two different levels, (3) the effect of chlortetracycline upon the utilization of inorganic and organic phosphorus by the pig, (4) the ability of the pig to utilize phosphorus from plant sources (phytin phosphorus), and (5) to determine the comparative value of organic and inorganic phosphorus for the growing and finishing pig.

Criteria of response were rate of gain, feed efficiency, daily feed intake and blood serum phosphorus when the pigs weighed 100 lb. These criteria, plus breaking strength, ash, phosphorus and fluorine content of the femurs were used when the pigs reached the terminating weight of 200 lb.

A comparison of feeding colloidal clay with either steamed bonemeal or dicalcium phosphate resulted in a significant decrease in rate of gain, feed efficiency and breaking strength of femurs, accompanied by a significant increase in ash content and an increase in the fluorine content of the femurs. There were no significant differences in the phosphorus content of bone ash or blood serum due to source of phosphorus supplementation.

Growing-finishing swine did not utilize plant phosphorus as efficiently as inorganic phosphorus, as evidenced by a significantly poorer feed

efficiency and decreased average daily feed intake when the phosphorus from the three supplements increased from 0.18 to 0.30 percent of the ration. There was also a significant linear increase in both final average daily gains and feed efficiency when phosphorus from plant sources decreased from 0.50 to 0.35 to 0.20 percent of the total ration, with inorganic phosphorus being added to maintain 0.5 percent phosphorus in the ration.

There were inconclusive indications that chlortetracycline may effect phosphorus metabolism in the bone of the growing-finishing pig.

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THE METHIONINE-CYSTINE NEED OF THE YOUNG PIG

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METHIONINE was initially recognized by Bell *et al.* (1950) as an essential amino acid for the growth of young swine. They suggested on the basis of their studies that the methionine requirement of growing pigs is between 0.07 and 0.27 percent of a diet containing 10 percent protein. Later, with a 21 percent protein diet, Shelton and coworkers (1951) observed maximal rate and efficiency of gain when the diet contained 0.6 percent methionine and 0.01 percent cystine. Furthermore, they noted that 0.3 percent cystine could satisfactorily replace an equal amount of methionine.

Curtin *et al.* (1952a, 1952b) presented evidence that the methionine need of the weanling pig is 0.7 percent of a 22 percent protein diet or 3.2 percent of the dietary protein. They also suggested that cystine could replace 53 percent of the methionine need. At the Illinois Station Becker *et al.* (1954a) calculated the amino acid needs of the pig on the basis of the minimum need for a protein of high biological value, namely, dried skim milk. Since the sulphur-bearing amino acids are the first limiting amino acids of milk protein an accurate estimate of the need for methionine plus cystine was obtained. According to these calculations, the pig of weanling size requires 0.46 percent methionine and at least 30 percent of the requirement can be satisfied with cystine.

The objectives of the studies reported here were to determine the minimum methionine-cystine requirement of the weanling pig and the effect of dietary antibiotic supplementation thereon. In addition, the ability of the weanling pig to utilize the calcium salt of DL-alpha-hydroxy-gamma-methylmercapto butyric acid as a source of methionine was investigated.

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Experimental

Two experiments were conducted with pigs weaned from sows which were fed adequate diets during gestation and lactation. A description of the diet used is given in table 1.

Sixty pigs of Yorkshire, Hampshire, or crossbred breeding were used in Experiment 1. Ten outcome groups of six pigs each were formed on

TABLE 1. PERCENTAGE COMPOSITION OF DIET FED

Ingredients:	
Isolated soybean protein (Drackett assay)	15.0
Corn starch	64.5
Dextrose	10.0
Woodflock	3.0
Corn oil	3.0
Mineral mixture #2 [a]	4.0
Vitamin A & D oil (3000A-600D)	0.5
Vitamin mixture #26 [b]	+
Protein and amino acid content:	
Protein (N × 6.25) [c]	12.62
Arginine	1.11
Histidine	0.35
Isoleucine	0.97
Leucine	1.02
Lysine [c]	0.71
Methionine [c]	0.15
Cystine [c]	0.17
Threonine	0.52
Tryptophan	0.14
Valine	0.75
Phenylalanine	0.67
Tyrosine	0.51

[a] The composition of mineral mixture #2 was as follows, in percent: $CaHPO_4$, 65.00; iodized NaCl, 16.00; K_2CO_3, 14.00; $MgCO_3$, 3.43; $FeSO_4 \cdot 7H_2O$, 1.00; $MnSO_4 \cdot H_2O$, 0.30; $CoCl_2 \cdot 6H_2O$, 0.10; $CuSO_4$, 0.10; NaF, 0.02; $ZnCO_3$, 0.04, and KI, 0.01.

[b] Vitamin additions per 100.0 lb. of diet were: thiamine HCl, 222.70 mg.; riboflavin, 443.20 mg.; pyridoxine HCl, 222.70 mg.; calcium pantothenate, 2.66 gm.; inositol, 8.86 gm.; p-aminobenzoic acid, 886.40 mg.; biotin, 3.40 mg.; nicotinic acid, 1.80 gm.; folic acid, 17.70 mg.; vitamin B_{12}, 1.36 mg.; choline chloride, 68.17 gm.; ascorbic acid, 1.36 gm.; a-tocopherol acetate, 340.90 mg.; and 2-methyl-1, 4-naphthoquinone, 88.60 mg.

[c] Values determined by analysis; other values were calculated.

the basis of ancestry, weight and general condition. The pigs were allotted to the methionine treatments at random from the outcome group, the outcome groups having been allotted at random to the antibiotic treatments. The pigs were kept by treatment groups in concrete pens, and the diets were self-fed *ad libitum* for four weeks. The methionine and antibiotic treatments are described in table 2. The calcium

salt of DL-alpha-hydroxy-gamma-methylmercapto butyric acid is hereafter referred to as methionine hydroxy analogue.

In Experiment 2, 32 weanling pigs of Hampshire, Yorkshire, Duroc and crossbred breeding were used. The pigs were grouped into eight outcome groups on the basis of ancestry, weight and general condition.

TABLE 2. PERFORMANCE OF WEANLING PIGS FED DL-METHIONINE AND METHIONINE HYDROXY ANALOGUE IN A DEFICIENT DIET (EXPERIMENT 1)

Supplement, %							
DL-methionine	—	0.10	0.20	0.30	0.40	—	
Methionine hydroxy analogue	—	—	—	—	—	0.20	Av.
Av. initial wt., lb.							
— Antibiotic	26.0	26.8	30.2	27.2	29.0	28.2	27.9
+ Antibiotic [a]	29.0	29.8	30.6	29.0	25.4	28.8	28.8
Av.	27.5	28.3	30.4	28.1	27.2	28.5	
Av. final wt., lb.							
— Antibiotic	38.6 [b]	50.8	54.4	44.8	49.0	54.2	48.6
+ Antibiotic	56.0	63.6	63.2 [b]	54.8	50.4	61.8	58.3
Av.	47.3	57.2	58.8	49.8	49.7	58.0	
Av. daily gain, lb.							
— Antibiotic	0.45 [b]	0.86	0.86	0.63	0.71	0.93	0.74
+ Antibiotic	0.96	1.21	1.16 [b]	0.92	0.89	1.18	1.05
Av.	0.71	1.03	1.01	0.78	0.80	1.05	
Av. daily feed intake, lb.							
— Antibiotic	1.45	2.19	2.26	2.09	2.05	2.18	2.04
+ Antibiotic	2.41	2.83	2.53	2.61	2.37	2.65	2.57
Av.	1.93	2.51	2.39	2.35	2.21	2.41	
Feed per lb. gain, lb.							
— Antibiotic	3.22	2.56	2.61	3.33	2.87	2.35	2.75
+ Antibiotic	2.50	2.34	2.17	2.83	2.66	2.25	2.43
Av.	2.73	2.43	2.36	3.03	2.75	2.29	

[a] A mixture of equal parts oxytetracycline HCl, procaine penicillin, and streptomycin at a rate of 36 mg. per lb.
[b] Includes a calculated missing value, since one pig failed to perform normally.

Individual pigs were allotted at random to the treatments. The feeding method and management practices were the same as in the previous test. The treatments are described in table 4.

In both experiments the growth data were treated statistically by analysis of variance as outlined by Snedecor (1946).

Results

The results of Experiment I are presented in table 2.

The methionine treatments did not show a significant interaction with antibiotics. However, the absolute increase in daily weight gains as a result of antibiotics in the diet tended to decrease with increasing levels of DL-methionine. For example, antibiotics produced an increment in daily gain of 0.51 lb. in the absence of supplementary methionine; whereas, in the presence of 0.4 percent of DL-methionine antibiotics produced an increase of only 0.18 lb. in daily gain.

Supplementary antibiotics in the diet yielded the usual improvement in performance. Pigs fed the antibiotic mixture exhibited a 42 percent greater rate of gain than the controls. In addition, supplementary antibiotics produced a 26 percent increase in feed intake and a 12 percent decrease in feed required per pound of gain.

TABLE 3. ANALYSIS OF VARIANCE OF MEAN DAILY GAINS OBTAINED IN EXPERIMENT 1

Source of variance	d/f	Mean square
Antibiotic level (A)	1	1.4821**
Outcome groups within A (G)	8	0.1302**
Methionine treatments (M)	5	0.2330**
A × M	5	0.0328
G × M	38	0.0378

** Significant at 1 percent level.

The supplementary levels of DL-methionine produced differences in rate of gain. Pigs fed the control diet exhibited suboptimal rate and efficiency of gains. Regardless of the antibiotic treatment, additions of 0.10 and 0.20 percent DL-methionine, which were sufficient to yield levels of 0.25 and 0.35 percent total dietary methionine, respectively, produced maximum response in rate of gain. There was no appreciable difference between these two levels of methionine. On the contrary, supplementary levels of 0.3 and 0.4 percent DL-methionine, which correspond to levels of 0.45 and 0.55 percent dietary methionine, respectively, were inhibitory to rate and efficiency of gain. However, the degree of inhibition did not appear to vary directly with the level of supplementary DL-methionine. The addition of 0.20 percent of methionine hydroxy analogue was equally as active as 0.10 or 0.20 percent of DL-methionine for improvement in rate and efficiency of gain.

As noted in table 3, the analysis of variance for Experiment 1 indi-

TABLE 4. PERFORMANCE OF WEANLING PIGS FED VARIOUS LEVELS OF L-CYSTINE IN A METHIONINE-DEFICIENT DIET (EXPERIMENT 2)

Supplement, %				
L-cystine	—	0.10	0.20	—
DL-methionine	—	—	—	0.20
No. of pigs	8	8	8	8
Av. initial wt., lb.	24.9	25.1	26.0	25.4
Av. final wt., lb.	41.2	41.5	44.6	55.1
Av. daily gain, lb.	0.58	0.58	0.67	1.06
Av. daily feed intake, lb.	1.85	1.94	2.13	2.54
Feed per lb. gain, lb.	3.17	3.31	3.20	2.39

cates a highly significant effect (P less than 0.01) of both antibiotic and methionine treatments upon weight gains.

On the deficient diet in the absence of antibiotics one pig failed to gain and died four days prior to the termination of the study. Autopsy revealed mild edema in both lungs, extensive areas of ulceration in the cardiac and pyloric regions of the stomach, and a mild fibrosis of the liver. Bacteriological study of the liver, spleen, and kidney was negative for pathogenic organisms. Another pig failed to exhibit normal performance in the group fed 0.20 percent DL-methionine plus antibiotics. The symptoms observed and the histopathological study of the skin indicated parakeratosis.

The results of Experiment 2 are presented in table 4.

In general, the level of performance of pigs fed the deficient diet in the latter study was similar to that noted in Experiment 1 in the lots which were not fed supplementary antibiotics. An addition of either 0.10 or 0.20 percent of L-cystine did not significantly enhance the performance of pigs fed the deficient diet. On the other hand, the addition of 0.20 percent DL-methionine yielded a marked improvement in rate of gain and efficiency of feed utilization. The analysis of variance, pre-

TABLE 5. ANALYSIS OF VARIANCE OF MEAN DAILY GAINS OBTAINED IN EXPERIMENT 2

Source of variance	d/f	Mean square
Treatments (T)	3	0.4192**
Outcome groups (G)	7	0.1237*
T × G	21	0.0492

* Significant at 5 percent level.
** Significant at 1 percent level.

sented in table 5, shows that the treatments exhibited a statistically highly significant effect (P less than 0.01) upon the weight gains.

Discussion

For the purpose of this discussion the D-isomer of methionine as present in a racemic mixture is regarded as equal in activity to the natural isomer for growth in the pig. In support of this stand, the D-isomer of methionine has been reported to be equal to the L-isomer for growth in the rat by Wretlind and Rose (1950), in the mouse by Bauer and Berg (1943) and in the dog by Stekol (1935).

Previous direct determinations of the methionine-cystine needs of the weanling pig have been conducted with diets containing a high level of protein. Shelton *et al.* (1951) fed purified diets containing 21 percent protein, and Curtin and co-workers (1952a) employed diets containing 22 percent protein from isolated soybean protein and brewers dried yeast. The use of high protein diets may yield a high requirement since Almquist (1952) has noted in chick nutrition that the sulfur-bearing amino acid requirement as a percent of the protein decreases as the protein level increases.

According to the data presented here, the methionine-cystine requirement of the weanling pig is 0.42 percent of a diet containing 12.6 percent protein. This value represents 3.33 percent of the protein, and apparently cystine can satisfy 40 percent of the total requirement. Previously Shelton *et al.* (1951) reported a value of 0.6 percent of a 21 percent protein diet and Curtin and co-workers (1952a) obtained a value of 0.7 percent on a 22 percent protein diet; these values correspond to 2.86 and 3.18 percent of the dietary protein, respectively. It is interesting that the indirect determination of the sulfur-bearing amino acid needs made by Becker *et al.* (1954a) revealed a requirement equal to 0.46 percent of a 12 percent protein diet which corresponds to 3.85 percent of the dietary protein. Hence, there appears to be some evidence in the pig for an indirect relationship between the sulfur-bearing amino acid requirement, expressed as a percentage of the protein, and the protein level of the diet.

There was no evidence that dietary antibiotics exerted a sparing action upon the methionine-cystine requirement of the pig. Previously Jones and Combs (1951) and Forbes (1954) have made similar observations in the chick and rat, respectively. It is true that supplementary antibiotics did increase the rate of growth on the methionine-deficient diet, although the improvement was only slightly greater than with the methionine-supplemented diets.

In the pig it seems that cystine can provide a portion of the total sulfur-bearing amino acid requirement; however, the evidence suggests that the replacement can be no greater than 40 percent of the total need. This value is somewhat less than the values of 50 and 53 percent reported by Shelton *et al.* (1951) and by Curtin *et al.* (1952a), respectively. In the chick, Almquist (1952) indicated that cystine may supply as much as 44 percent of the sulfur-bearing amino acid need. However, Rose and co-workers (1948) reported that, in the rat, cystine can provide only about 17 percent of the total need for methionine. If the replacement value of cystine noted in the rat applied to the pig, then the total sulfur-bearing amino acid need of weanling swine would be in the order of 0.30 percent of a 12.6 percent protein diet or 2.38 percent of the dietary protein. Further study on this point seems warranted.

The evidence presented here demonstrates that the calcium salt of alpha-hydroxy-gamma-methylmercapto butyric acid can be utilized by the pig to at least partially satisfy the methionine requirement. Previous observations made with the chick by Bird (1952) and by Gordon *et al.* (1954) demonstrate that the methionine hydroxy analogue can also be utilized by the avian species.

Inhibition of growth by feeding excessive levels of methionine has been studied extensively in the rat. Brown and Allison (1948) observed that an addition of 4.8 percent of DL-methionine to a 12 percent casein diet produced weight losses in the rat, and also that the addition of 1.7 percent arginine would overcome part of the deleterious effects. Van Pilsum and Berg (1950) reported that excessive methionine in an amino acid mixture would suppress the growth of the rat, and they also observed that additions of glycine or arginine overcame the growth retardation. Similar observations have been reported by Wretlind and Rose (1950) when 1.4 percent L-methionine was fed in a synthetic diet for the rat.

Recently Henson *et al.* (1954) reported that an addition of 0.2 percent DL-methionine to a corn-tankage ration produced a growth inhibition in the pig; however, methionine did not produce this effect when supplementary tryptophan was added. It is noteworthy that growth retardation was noted with levels of methionine lower than that considered merely nutritionally adequate in higher protein diets employed by other workers.

From the practical viewpoint, the studies presented here tend to emphasize the lack of need for supplementary methionine in practical rations. According to Becker *et al.* (1954b), normal performance of

the weanling pig was noted when feeding a corn-soybean oil meal ration containing 14 percent protein and 0.23 percent methionine (no measurement of cystine). In agreement with our data, Catron *et al.* (1953) found that corn-soybean oil meal diets formulated to yield either 12 or 14 percent protein were not improved by supplementary methionine. According to calculations of the authors a 12 percent protein corn-soybean oil meal diet would contain about 0.22 percent methionine and 0.17 percent cystine. However, with a diet in which soybean oil meal contributes the sole or major source of protein supplementary methionine is essential as soybean protein contains only 1.1 percent methionine.

Summary

Weanling pigs weighing approximately 28 lb. were used to measure the methionine-cystine requirement and the effect of dietary antibiotics thereon. A synthetic diet containing 12.6 percent isolated soybean protein and 0.15 percent methionine plus 0.17 percent cystine was deficient in methionine to support normal performance of the weanling pig. Additions of 0.1 or 0.2 percent of L-cystine to the deficient diet failed to improve performance.

A level of 0.25 percent methionine in the presence of 0.17 percent cystine supported satisfactory rate and efficiency of gain. Expressed as a percentage of the dietary protein the combined methionine-cystine requirement is approximately 3.33 percent of the protein. Cystine can apparently provide about 40 percent of the need for sulfur-bearing amino acids.

Supplementary levels of 0.3 or 0.4 percent DL-methionine produced an inhibition of growth.

The weanling pig can utilize DL-alpha-hydroxy-gamma-methylmercapto butyric acid to at least partially satisfy the methionine requirement for normal growth.

Dietary antibiotics produced a marked improvement in the rate and efficiency of gains. However, antibiotics did not influence the response of the pig to levels of DL-methionine or to methionine hydroxy analogue.

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THE INFLUENCE OF CHLORTETRACYCLINE ON THE GROWTH AND CARCASS CHARACTERISTICS OF SWINE FED RESTRICTED RATIONS [1]

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THE value of certain antibiotics for the growing-fattening pig fed an unrestricted ration has been amply demonstrated (Braude *et al.*, 1953). The antibiotic effect is at least partially manifested in an increased feed consumption, which in turn produces faster gains. This was demonstrated in studies by Brown *et al.*, 1952.

In much of the Southeastern section of the United States and particularly in Florida, there is an ever-present shortage of grains and concentrated feed materials for swine feeding. Thus, limited grain feeding of swine is not uncommon. The value of antibiotics under conditions of limited feeding has not been adequately determined. Recent attention to the production of the meat-type market hog has also emphasized the need for such information since restricted feeding is one method of producing a meaty carcass. This study was undertaken to observe the effects of chlortetracycline on the growth, feed efficiency, and carcass value of animals fed restricted rations under both drylot and pasture conditions.

Experimental Procedure

Animals

Three experiments, one in drylot and two in pasture, constituted the study. All pigs used in the experiments were weaned at eight weeks of age and were started on the experimental rations at approximately nine weeks of age. Experiment I (Drylot) included 28 purebred Duroc and 28 purebred Hampshire pigs. Experiment II (Pasture) included 9 purebred Durocs, 9 Duroc × Spotted Poland China, and 6 purebred Hampshires. Thirty purebred Duroc pigs were fed in Experiment III (Pasture). The animals were carefully allotted according to breed, litter, weight, sex, and previous dietary history to the various experimental groups in each experiment. The drylot test (Experiment I) was conducted in concrete pens which were cleaned and washed daily.

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Experimental Rations

The composition of the rations fed in the three experiments is given in table 1. Experiment I was conducted in concrete pens. Experiment II was conducted on millet pasture. In Experiment III the pigs were fed on pasture which consisted of a mixture of sweet yellow lupine and oats for the first six weeks and during the remainder of the test they were fed on a mixture of crimson, ladino and Kenland red clover. The rations were hand fed once per day (morning) in all experiments. The feed allowances of the restricted groups were determined according to the amount of feed consumed by the respective control or unlimited groups. Near the termination of the experiments, when all full-fed animals had

TABLE 1. PERCENTAGE COMPOSITION OF EXPERIMENTAL RATIONS

Ingredient	Expt. I [a]	Expt. II	Expt. III
Ground yellow corn	78.0	78.0	83.0
Soybean oilmeal	15.0	15.0	15.0
Alfalfa meal	5.0	5.0	...
Ground limestone	1.0	1.0	1.0
Steamed bonemeal	0.5	0.5	0.5
Salt-trace minerals [b]	0.53	0.53	0.53

[a] The following levels of B-complex vitamins per 100 lb. of feed were added to the ration fed in Experiment I: thiamine, 1.0 gm.; riboflavin, 230 mg.; niacin, 2.33 gm.; pantothenic acid, 1.0 gm.; pyridoxine, 375 mg.; choline chloride, 19.4 gm.; folic acid, 22.7 mg.; and B_{12}, 1.0 mg. These vitamins were generously supplied by Lederle Laboratories, Pearl River, New York. No vitamins were added to the rations fed in Experiment II and III.

[b] The salt trace mineral mixture was composed of: iodized salt, 50 lb.; manganese sulfate, 921 gm.; ferrous sulfate, 398 gm.; copper sulfate, 125 gm.; and cobalt carbonate, 10 gm.

been slaughtered, the allowance of the restricted animals was continued at a level based on the last consumption level of the full-fed animals. When chlortetracycline was included in the ration as indicated in tables 2 and 3, it was added at a rate of 20 gm. per ton of feed. Crystalline Aureomycin was fed in Experiment I and II. In Experiment III the antibiotic was included as Aurofac 2-A. All rations contained approximately 14 percent of crude protein.

Slaughter Procedure and Carcass Measurements

All animals in Experiment I were slaughtered individually as they reached a final weight of approximately 190 lb. Carcass yields were calculated on the basis of final live weight and the warm carcass weight (leaf fat in, head on). Thickness of back-fat was calculated by averaging the measurements taken at the first rib, last rib, and last lumbar vertebra. Carcass length was measured from the anterior edge of the first

TABLE 2. THE EFFECT OF AUREOMYCIN ON THE PERFORMANCE OF PIGS FED RESTRICTED RATIONS IN DRYLOT

(Exp. I)

Lot number	1	2	3	4	5	6	7
Experimental rations	Unrestricted	Same level of feed intake as lot 1 [a]	Unrestricted [a]	Allowed 80 percent of the feed consumed by lot 1	Allowed 80 percent of the feed consumed by lot 1 [a]	Allowed 60 percent of the feed consumed by lot 1	Allowed 60 percent of the feed consumed by lot 1 [a]
No. of pigs	8	8	8	8	8	8	8
Av. initial wt., lb.	43.8	44.1	43.5	44.1	43.3	44.3	43.9
Av. daily gain, lb.	1.43	1.50	1.60	1.29	1.27	0.99	1.01
and standard error	±0.04	±0.05	±0.04	±0.05	±0.03	±0.03	±0.02
Av. final slaughter wt. lb.	189.4	193.4	194.5	194.1	187.9	192.4	191.5
Feed per lb. gain, lb.	3.46	3.29	3.40	3.31	3.29	3.43	3.41
Feed cons. per pig/day	4.93	4.90	5.43	4.21	4.16	3.39	3.42
Back fat thickness, in.	1.64	1.68	1.79	1.67	1.60	1.58	1.65
Warm dressing percentage	79.25	78.43	79.74	78.48	78.81	80.18	81.12
Carcass length, in.	28.24	28.41	28.53	28.53	28.38	28.44	28.32
Percent lean cuts	44.57	44.08	43.95	43.93	44.65	45.76	44.20
Av. no. days on test	102.3	100.3	94.5	118.0	114.5	149.8	146.8

[a] Plus chlortetracycline.

rib to the anterior edge of the aitch bone. The carcasses were cut according to standard packing house procedures with a 2½-rib shoulder. Percentage of lean cuts was calculated by relating the combined weights of the hams, picnic shoulder, boston butts and loins to the chilled carcass weights. The hams were faced leaving one-half inch of fat on the front of face with the facing running back to skin thickness about one-third of the way back to where the bulge of the ham meets the hock. Excess fat was trimmed from the shoulders leaving a one-half inch face. The loins and boston butts were trimmed leaving approximately one-half inch of fat covering.

TABLE 3. THE EFFECT OF AUREOMYCIN ON THE PERFORMANCE OF PIGS FED RESTRICTED RATIONS ON PASTURE

	Experiment II			Experiment III		
Lot No.	1	2	3	1	2	3
Item	Unrestricted	Same level of feed intake as Lot 1 [a]	Unrestricted [a]	Unrestricted	Allowed 60 percent of the feed consumed by Lot 1	Allowed 60 percent of the feed consumed by Lot 1 [a]
No. of pigs	8	8	8	10	10	10
Av. initial wt., lb.	39.6	39.4	39.5	42.1	42.1	42.7
Av. daily gain, lb.	1.33	1.42	1.42	1.47	.98	1.03
and standard error	±0.02	±0.04	±0.02	±0.06	±0.06	±0.04
Av. final wt., lb.	182.9	182.4	184.5	198.1	195.0	194.7
Feed per lb. gain, lb.[b]	3.67	3.43	3.40	3.35	3.64	3.44
Feed com. per pig per day, lb.	4.80	4.83	4.77	4.90	3.47	3.45
Back fat thickness, in.	.....	.....	.....	1.93	1.53	1.53
Warm dressing percentage	.....	.....	.....	79.95	75.82	76.60
Carcass length, in.	.....	.....	.....	28.19	28.61	28.37
Percent lean cuts	.....	.....	.....	43.48	47.41	46.99
Av. No. days on test	107.6	101.5	102.4	106.4	154.9	151.5

[a] Plus chlortetracycline.
[b] In addition to pasture.

The animals in Experiment II were not slaughtered for carcass measurements.

In Experiment III, 5 animals from Lot 1, 8 from Lot 2 and 9 from Lot 3 were slaughtered when they reached an approximate weight of 195 lb. Carcass measurements were obtained in the same manner as for Experiment I.

Results and Discussion

A summary of the experimental results is presented in tables 2 and 3 and a statistical analysis of the data is given in table 4.

Experiment I

Average Daily Gains. The gains of the pigs in the drylot experiment (table 2) indicated no advantage for the use of chlortetracycline when the feed intake was controlled. There was a slight improvement in average daily gains in Lot 2 which received antibiotic compared to Lot 1 which received the same amount of feed but no antibiotic. However, this was not statistically significant. Lot 3 was fed chlortetracycline and feed intake was not restricted. Animals in this lot ate more feed and gained faster than animals in Lot 2. The difference in rate of gain approached

TABLE 4. SUMMARY OF STATISTICAL ANALYSES [a]
(Exp. I, lot 3 excluded)

Source of variation	Degrees of freedom	Average daily gain	Warm dressing percent	Back fat thickness	Carcass length	Percent of lean cuts
	d.f.	m.s.	m.s.	m.s.	m.s.	m.s.
Level of feeding	2	.8619**	19.42*	.0099	.0709	2.96
Antibiotic	1	.0054	.25	.0017	.0154	2.15
Level of feeding × antibiotic	2	.0121	3.21	.0228	.1311	8.55
Error	42	.0119	5.24	.3113	.8734	4.64
		(Exp. II)				
Lots	2	.02	...	...	...	...
Error	21	.01	...	...	...	...
		(Exp. III) [b]				
Lots	2	.74**	22.99	2.71**	.26*	27.37**
Error	27	.03	7.09	0.03	.06	4.36

[a] Analysis of variance using the method described by Snedecor (1946).
[b] Degrees of freedom for dressing percentage and percent of lean cuts was 21; for back fat thickness and carcass length 19.
* Significant at 5 percent level.
** Significant at 1 percent level.

significance. Lots 4 and 5 were restricted to 80 percent of a full ration. The feeding of antibiotic to Lot 5 did not improve gains. Similar results were obtained in Lots 6 and 7 which were fed 60 percent of a full ration. These pigs gained much slower but again the antibiotic did not improve weight gains.

As would be expected, the level of feeding had a marked influence on the rate of gain. These differences were highly significant. The performance of pigs within the lots was quite uniform in all cases.

Feed per Pound Gain. Lots 1 (unrestricted), 2 (same level of feed intake as Lot 1 with antibiotic) and 3 (unrestricted with antibiotic)

required 3.46, 3.29 and 3.40 lb. of feed per pound of gain respectively. The presence of chlortetracycline in the ration of Lot 2 appeared to improve feed utilization. Animals fed 80 percent of a full ration (Lots 4 and 5) required 3.31 and 3.29 lb. of feed per pound of gain respectively. Chlortetracycline had no significant effect on feed utilization. Animals fed 60 percent of full ration (Lots 6 and 7) required 3.43 and 3.41 lb. feed per pound of gain respectively. Again, chlortetracycline exerted no significant effect on the utilization of feed when feed intake was held the same. It is interesting to note that the utilization of feed was slightly lower at the 60 percent level of feed intake than at the 80 percent level of intake. A moderate restriction of feed consumption (80 percent level) improved feed conversion in this experiment.

Effect on Carcass. Dressing percentages were significantly higher for the animals which were restricted to 60 percent of a full ration. These animals were very trim about the middle and produced a minimum of wastage at slaughter. Dressing percentages for the other five lots averaged significantly less but were not greatly different one from the other. Of these five lots, the unrestricted group which received chlortetracycline (Lot 3) recorded the highest dressing percentage. The data in this experiment showed that the antibiotic, per se, had very little or no effect on dressing percentage or on back fat thickness when feed intake was controlled.

There were no significant differences in average thickness of backfat or carcass length between the various dietary treatments. The percentage of lean cuts was not significantly affected by reducing the feed intake. Chlortetracycline had no effect on the percentage of lean cuts at any of the levels of feeding.

Experiment II

Average Daily Gains and Feed per Pound Gain. In this experiment, the pigs were fed on millet pasture. Average daily gains (table 3) for the three groups of pigs in the experiment were Lot 1 (Unrestricted) 1.33 lb., Lot 2 (Same level as Lot 1 plus antibiotic) 1.42, and Lot 3 (Unrestricted plus antibiotic) 1.42 lb. Antibiotic produced a small increase in rate of gain, although not statistically significant, and also slightly improved feed efficiency in both Lots 2 and 3. Average daily feed consumption was practically the same for all three lots. No marked differences in forage consumption were noted.

Experiment III

Average Daily Gains. The gains of the three groups of pigs fed in this test are shown in table 3. The unrestricted group (Lot 1) gained at a rate of 1.47 lb. per day. Restriction of feed intake to 60 percent of a full ration (Lot 2) reduced gains to .98 lb. per day. The addition of chlortetracycline to the restricted ration (Lot 3) did not improve gains significantly.

Feed per Pound Gain. The unrestricted group required 3.35 lb. of feed per pound of gain. The restricted group without antibiotic required 3.64 lb. of feed and the restricted group with antibiotic required 3.44 lb. of feed per pound of gain. Animals in this study had access to excellent forage throughout the experiment. It was observed that the pigs which were fed chlortetracycline consumed more forage and were more uniform in growth performance. Brinegar and Warner have also reported that antibiotic supplementation under reduced feed consumption conditions increased forage consumption.

Effect on Carcasses. Dressing percentages were significantly lower for the limited-fed pigs in this test which is in contrast to the results under drylot conditions in Experiment I. The heavy consumption of forage by the pigs on limited feeding resulted in very wasty middles compared to the trim animals in the drylot study. The marked differences in dressing percentage are probably thus explained.

Backfat thickness was 1.93 inches for the unrestricted group and 1.53 inches for each of the restricted groups. Antibiotic did not influence backfat thickness. Carcass lengths of the restricted groups were somewhat greater than for the unrestricted group which was probably due to the fact that they gained slower and were older at the time of slaughter. The percentage of lean cuts was greatly increased by feed restriction but was not significantly affected by chlortetracycline supplementation.

Summary

Three experiments, one in drylot and two on pasture, have been conducted to determine the influence of chlortetracycline (Aureomycin) on the growth, feed utilization and carcass quality of growing-fattening swine fed limited rations. A total of 110 pigs were used in the trials.

The results indicate that antibiotic was not beneficial to healthy pigs fed restricted rations under drylot conditions when feed intake of the antibiotic-fed animals was limited to that of the controls. Under these conditions it was shown that chlortetracycline, per se, had very little or no effect on dressing percentage or on backfat thickness. However, when

concentrates were fed on pasture the antibiotic appeared to have induced a greater forage consumption and thus produced gains somewhat more efficiently, although the rate of gain was not significantly improved.

Aureomycin had no effect on the carcass measurements of the pigs under any of the feeding regimes. Feed restriction in drylot produced carcasses that were higher in dressing percentage but not greatly different from full-fed animals, in percentage of lean cuts, in backfat thickness and carcass length. On pasture the restriction of feed produced carcasses which were much higher in percentage of lean cuts, much lower in backfat thickness and somewhat lower in carcass yield.

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SUGAR IN PIG STARTERS [1, 2]

C. J. Lewis, D. V. Catron, G. E. Combs, Jr., G. C. Ashton and C. C. Culbertson [3]

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BETTER and more palatable pig starters are needed whether pigs are creep-fed while nursing sows or early-weaned at 1 to 3 weeks of age. They provide the most practical, economical and direct way to secure adequate nutrition for the baby pig.

Although palatability studies have been conducted with the baby pig by Carroll (1942), Krider and Terrill (1950), Terrill *et al.* (1952), Terrill *et al.* (1951), Meade (1953) and Nelson *et al.* (1953), no control has been exercised either over variations in quantity and quality of milk that the baby pig received or over place and feeder preference.

Because of the baby pig's inherent desire for its mother's milk, any feed that is to compete for a place in the baby pig's diet, or replace its mother's milk, must not only be nutritionally adequate, but also highly palatable.

The objective of these experiments initiated in the fall of 1952 was to develop highly palatable, nutritionally adequate starters that baby pigs would consume in large quantities at an early age.

Experimental

The experimental animals used in these experiments were crossbred Poland China-Landrace-Duroc pigs. They were housed in concrete block buildings with radiant heated concrete floors. The environmental temperature, which was thermostatically controlled, was maintained at 65–70° F. and to insure adequate floor temperature, heat lamps were provided from birth to 4 weeks of age.

Because of the variation in the quantity and quality of sow's milk, and the number of pigs per litter, most of the pigs were weaned at 1 week of age and a controlled synthetic milk feeding program was followed. The composition of the synthetic-milk solids was 87.6 percent

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dried skimmilk, 8 percent lard, 2 percent lecithin, fortified with vitamins, minerals, trace minerals, and antibiotics. The milk was mixed 12 hours prior to feeding, refrigerated, and then fed cold.

The percentage composition of the basal pig starter was, cold-rolled oat groats 40, ground yellow corn 35.9, fish meal 2.5, dried whey (low lactose) 2.5, and solvent soybean oil meal 14.0; it was fortified with vitamins, minerals, trace minerals and antibiotics. Cane sugar and rolled oat groats were substituted for corn and soybean oil meal to maintain a constant protein level. The calculated analysis was, crude protein 18

TABLE 1. EXPERIMENTAL METHODS AND PROCEDURES

Exp. no.	No. of pigs per lot	No. of replicates	Age off sow (da.)	Method of milk feeding	Age off exp. (wk.)
588A	8	2	7	Full-fed 7–14 days of age,	8
588B	8	2	7	constant 14–21, reduced and removed by 28 days of age.	8
588C	4	10	3	Full-fed 3–14 days, then same as Exp. 588A	8
588D	4	2	7	Same as Exp. 588A	8
590A	5	8	7	Varied	5
590B	5	5	7	Varied	5
590C [a]	..	5	..	Nursed sows	5
599	4	6	7	Full-fed 1–2 weeks, reduced and removed by 3 weeks of age.	8

[a] Two litters.

percent, fat 3.7 percent, fiber 2.6 percent, calcium 1.25 percent, phosphorus .85 percent; and, per lb., vitamin A 4942 I.U., vitamin D_2 1000 I.U., riboflavin 5 mg., pantothenic acid 10 mg., niacin 32.7 mg., choline 634 mg., folic acid .5 mg., vitamin B_{12} 21 mcg. and terramycin 51 mg. The pellets used were 3/16 inch in diameter and about $\frac{3}{8}$ inch long.

In all experiments where more than one starter was offered to each lot of pigs, the feeders were randomly rearranged twice each week in order to prevent place preference. Extra precautions were taken to get accurate feed consumption data.

The pigs were allotted to treatments by weight outcome groups within litters. The methods and procedures followed for the different experiments reported herein are shown in table 1.

Results

Experiment 588A was designated to determine the baby pig's preference for level of cane sugar and form of pig starter. Twelve starters (meals containing 0, 5, 10, 15 and 20 percent sugar; pellets containing 0, 5, 10, 15, and 20 percent sugar; and, 10 percent and 20 percent sugar-coated pellets) were offered in separate self-feeders simultaneously. The results presented in table 2 show that a pellet containing 20 percent sugar on the inside was definitely preferred. Pellets were

TABLE 2. EXP. 588A—EFFECT OF SUGAR LEVEL AND FORM OF STARTER ON PIG STARTER PREFERENCE

	Sugar level (%)					
Form of starter	0	5	10	15	20	Total
	(Pounds consumed per pig)					
Meal	.09	.11	.09	.09	.26	.64
Pellets	.15	.36	1.26	3.12	76.50	81.39
Sugar coated pellets	...	...	.22	...	2.73	2.95
Total	.24	.47	1.57	3.21	79.49	84.98

(Av. per pig)

Total starter	85.0 lb.	56 day wt. =	60.3 lb.
Milk solids	9.0 lb.	7 day wt. =	6.4 lb.
Total feed	94.0 lb.	Total gain	53.9 lb.

Feed per lb. gain = 1.74 lb.
Av. daily gain = 1.10 lb.

preferred to meal, and as the sugar level increased starter consumption increased. The consumption patterns between replicates were consistent.

In experiment 588B, designed to test oat groat levels and sugar levels, 12 starters were again offered simultaneously in separate self-feeders: No-sugar pellets containing 0, 10, 20 and 40 percent oat groats; 15 percent sugar-coated pellets containing 0, 10, 20 and 40 percent oat groats; and pellets with 15 percent sugar inside containing the same levels of oat groats.

The consumption patterns in experiment 588B (table 3) were rather erratic. Except for the preference of sugar over no sugar, there was little consistency of consumption either within or between replicates. This phase of these studies was the only case in which sugar-coated pellets were preferred to pellets with sugar inside.

TABLE 3. EXP. 588B--EFFECT OF OAT GROAT LEVEL AND POSITION OF SUGAR ON PIG STARTER PREFERENCE

Level and position of sugar (all pellets)	Oat groats (%)				
	0	10	20	40	Total
	(Pounds consumed per pig)				
No sugar	.10	.39	.17	.05	.71
15% sugar inside	6.18	.60	.80	10.14	17.72
15% sugar coated	28.69	1.16	13.61	36.91	80.37
Total	34.97	2.15	14.58	47.10	98.80

(Av. per pig)

Total starter	98.8 lb.	56 day wt. =	65.7 lb.
Milk solids	8.6 lb.	7 day wt. =	6.2 lb.
Total feed	107.4 lb.	Total gain	59.5 lb.

Feed per lb. gain = 1.80 lb.
Av. daily gain = 1.21 lb.

Figure 1 is a picture of seven-week-old pigs that were representative of all pigs in experiments 588A and 588B.

The objective of experiment 588C was to determine the particle size or form of starter that baby pigs preferred. Three starters, identical in composition, were offered simultaneously in meal, crumble, and pellet forms. These crumbles were carefully prepared so that very few "fines" were allowed to accumulate.

Figure 1. Typical seven week old pigs. Pen arrangement shows battery of self-feeders used for simultaneous palatability studies. Feeders were randomly re-arranged twice each week in order to prevent place preference.

Table 4 shows that crumbles and pellets were preferred to the meal when all were offered simultaneously free-choice. Over the entire test, a significantly larger quantity of crumbles was consumed than pellets or meal. The consumption ratio of pellets to crumbles tended to decrease with the age of the pigs after the third week. This may indicate that as the pigs became larger, pellets became more preferable.

In order to test the starters individually, a fourth experiment, 588D, was conducted. Five starters, meals containing 0 and 20 percent sugar, pellets containing 0 and 20 percent sugar, and a 20 percent sugar-

TABLE 4. EXP. 588C—EFFECT OF FORM OF STARTER ON BABY PIGS STARTER PREFERENCE

Age Weeks	Form of starter			Ratio
	Meal	Pellets	Crumbles	Pellets:Crumbles
	(Pounds consumed per pig)			
1–2	.03	.06	.09	1:1.5
2–3	.02	.30	.36	1:1.2
3–4	.06	1.70	3.77	1:2.2
4–5	.81	3.97	8.04	1:2.0
5–6	.15	6.95	10.22	1:1.5
6–7	.92	10.39	11.90	1:1.1
7–8	.63	12.19	13.55	1:1.1
	(Av. per pig)			
Feed per lb. gain = 1.66 lb.			Av. 56 day wt. = 56.2 lb.	

coated pellet were tested. The five starters were offered to separate replicated lots of pigs.

The results of this experiment are shown in figure 2. Since milk was fed until 4 weeks of age, only the 4- to 8-week data were statistically tested. During the 4- to 8-week period, the pigs making the least gain, 34.4 lb., were on a meal starter containing no sugar. The pigs making the most gain, 39.2 lb., were on a pelleted starter containing 20 percent sugar on the inside. However, these differences in gain were not statistically significant at the 0.05 level.

The inclusion of sugar, whether in meal or pellets, significantly decreased the feed required per pound of gain as compared to no sugar starters of the same form. Pelleting alone significantly decreased the feed required per pound of gain. Thus, there was an additive effect when starters containing sugar were pelleted.

Experiment 590 was divided into three phases (figure 3). The purpose

of phase A was to study further the effect of sugar level on the baby pig's starter preference. Four pelleted starters, containing 0, 10, 15, and 20 percent sugar, were offered in separate self-feeders simultaneously. The purpose of phase B was to study the effect of position of the sugar

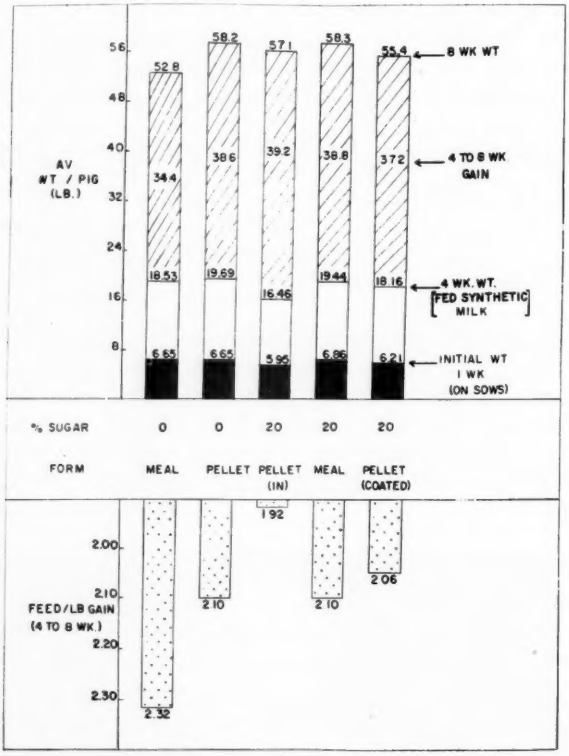

Figure 2. Experiment 588D. Influence of form of pig starter and presence of sugar in pig starter on gains and feed efficiency.

(inside, coated or both) on starter preference. Three pelleted starters were offered simultaneously, 20 percent sugar inside, 10 percent sugar inside plus 10 percent sugar coated, and 20 percent sugar coated. In purpose and ration treatments, phase C was identical to phase B except that the starters were creep-fed and the baby pigs were allowed to nurse the sows.

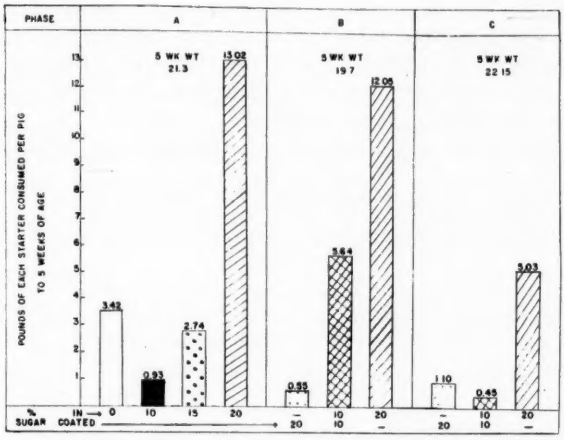

Figure 3. Experiment 590. Summary of free-choice starter consumption.

From previous experiments it was thought that possibly the baby pigs had a feeder preference, although the feeders were identical. To test this hypothesis, phase C, each starter was offered in two feeders. Thus in each lot of creep-fed pigs there were six feeders with only three starters (see table 5). These feeders were also randomly rearranged twice each week in order to prevent place preference.

In all phases of experiment 590, the pigs preferred a starter containing 20 percent sugar on the inside (figure 3). This is in agreement with experiment 588A as high levels of sugar were preferred and pellets containing sugar on the inside were preferred to sugar-coated pellets.

TABLE 5. EXP. 590C—POUNDS OF STARTER CONSUMED FROM EACH SELF-FEEDER WHEN THE SELF-FEEDERS ARE REPLICATED WITHIN EACH LOT [a]

Lot no.	No. of pigs	20 (in)	20 (out)	10 in 10 out	20 (in)	20 (out)	10 in 10 out
6	17	12.6	20.3	0.9	45.2	40.9	4.4
7	18	29.5	3.5	0.8	56.4	12.6	1.6
8	13	72.1	2.5	2.2	51.7	1.6	1.0
9	12	17.8	1.0	4.8	17.6	0.9	2.7
10	19	62.0	2.1	2.7	32.1	1.2	14.7
Total	79	194.0	29.4	11.4	203.0	57.3	24.4

[a] Six identical self-feeders in each lot, two for each starter (creep-fed).

In all lots, with the exception of lot 6 (table 5), consumption within each battery of feeders was highest for a starter containing 20 percent sugar on the inside. This is not meant to imply that baby pigs do not have a feeder preference, but rather that the results of this experiment were not influenced by a feeder preference.

Experiment 599 was designed to determine when sugar would be most

TABLE 6. EXP. 599. EXPERIMENTAL PLAN AND 56-DAY PIG WEIGHTS

Farrow	1–5 wk. ration [a]	5–8 wk. ration [b] (Amount of sugar)	Weeks of age: Average 56 day wt. (Pounds)
On sow	0% Sugar	0	34.8
	←Snyth.→ Milk	7½%	40.0
		15%	39.1
	15% Sugar coated	0	33.8
		7½%	40.2
	←Synth.→ Milk	15%	39.2
	15% Sugar (inside)	0	37.0
		7½%	41.6
	←Synth.→ Milk	15%	40.0

[a] Six lots of pigs on each 1–5 week ration treatment.
[b] Two lots of pigs on each 5–8 week ration treatment.

beneficial in the starting period. The design and 8-week body weights are shown in table 6. From 1 to 5 weeks of age three starter treatments were tested, pellets with 0 percent sugar, 15 percent sugar, and a 15 percent sugar-coated pellet. On each starter treatment there were six lots of four pigs each. At 5 weeks of age, from each 1 to 5 week treatment, two lots of pigs were changed to a starter containing 0 percent sugar, two lots to 7.5 percent sugar and two lots to 15 percent sugar (sugar inside the pellets).

The results of the two feeding intervals of experiment 599 are given in table 7. The inclusion of 15 percent sugar (inside the pellet) resulted in a significant increase over no sugar in 3 to 5 week gains. Also, 15 percent sugar-inside pellets significantly decreased the feed required per pound of gain when compared to 15 percent sugar-coated pellets.

The higher requirement of feed per pound of gain of the pigs fed the sugar-coated pellets may be due largely to feed wastage because of the tendency of these pellets to cake within the feeder and feeder lip. This caking condition seemed to be brought about by multiple conditions,

TABLE 7. EXP. 599—EFFECTS OF SUGAR LEVEL AND POSITION OF SUGAR ON GAIN AND FEED UTILIZATION IN RELATION TO INTERVAL IN THE STARTING PERIOD

From 3 to 5 weeks of age [a]			
	% Sugar		
Items	0	15 (in)	15 (coated)
5 week weight, lb.	16.6	19.5	16.9
3–5 week gain, lb.	6.8	8.9 [b]	7.1
Feed per lb. gain, 3–5 wk.	1.84	1.69 [c]	1.98

From 5 to 8 weeks of age			
	% Sugar		
Items	0	7.5 (in)	15 (in)
8 week weight, lb.	35.2	40.6	39.45
5 to 8 week gain, lb.	19.1	21.9	21.3
Feed per lb. gain, 5–8 wk.	1.91	1.94	1.92

[a] Milk-free period.
[b] Significant increase over 0 sugar and 15 percent coated at P = 0.05 or less.
[c] Significant decrease when compared to 15 percent sugar coated at P= 0.05 or less.

such as saliva contamination while eating, a tendency for the pigs to suck the pellets, contamination of the pellets with liquid immediately after drinking milk or water, and a high environmental humidity and temperature. The latter factors, temperature and humidity, are probably the most important as only during the late spring and summer months was this difficulty encountered. In such cases the lips of the feeders were cleaned twice each day.

In the 5 to 8 week period, an increase in gains was again observed with the inclusion of sugar. However, none of these differences was statistically significant at the 0.05 level.

The 8-week weights were lower than obtained in previous experiments. Apparently this was due not only to a greater restriction in milk feeding, but also to a higher disease level during this experiment.

In table 8 the starter consumption per pig by weeks from 1 to 5 weeks is given. The addition of sugar, whether inside or coated, increased starter consumption during every week. Although only in the third week was starter consumption significantly increased by the inclusion of sugar, it is believed that some real difference does exist as each figure represents the average feed consumption of 24 pigs, the feeders were weighed to 0.01 lb. and the difference in total consumption is

TABLE 8. EXP. 599—INFLUENCE OF SUGAR AND SUGAR POSITION ON EARLY STARTER CONSUMPTION

Description	Age (weeks)				Total
	1–2	2–3	3–4	4–5	
	(Pounds consumed per pig)				
0% Sugar	0.05	1.24	4.51*	7.79	13.60*
Synth. milk	2.26	1.46			
15% Sugar (out)	0.20	1.58	5.62	8.18	15.58
Synth. milk	2.15	1.36			
15% Sugar (in)	0.17	1.68	5.50	9.23	16.57
Synth. milk	2.37	1.41			

* Effect of sugar (in or out) over no sugar significant at $P = 0.05$ or less.

statistically significant. The fact that the starter consumption was significantly increased the third week (the week after synthetic milk feeding ceased) suggests that sugar in starters improves palatability and thereby aids in the transition from a liquid to a dry diet. Support of this theory is indicated by the 5-week body weights (table 7).

Discussion

In all preference studies, the baby pigs selected starters containing sugar. In all experiments except one, the pigs preferred a pelleted starter containing 20 percent sugar inside. In the exception (experiment 588B), 15 percent sugar-coated pellets were preferred to pellets containing either 15 percent sugar inside or no sugar. However, in this experiment, there was no consistency in selection either within or between lots of pigs.

The results of these experiments agree with work reported by Nelson *et al.* (1953) and Hanson *et al.* (1954), in that sugar increases palata-

bility. They are contradictory to the work of Nelson *et al.* (1953), in that in most cases the baby pigs in these experiments preferred sugar inside the pellets to sugar-coated pellets.

Although results obtained in experiment 588B with oat groat levels were erratic, they may suggest that oat groats are not as important in pig starters as previously thought, or that sugar tends to mask any effect that oat groats may have on palatability. Hanson *et al.* (1954) experienced similar results.

Terrill *et al.* (1951), reported that pellets were preferred to meal. Nelson *et al.* (1953), have also shown that pellets were preferred to either crumbles or meal. These experiments are in agreement in that pellets were preferred to meal; however, they do not support the work of Nelson *et al.* (1953), in that in these experiments crumbles were preferred to pellets. The explanation of the difference between the results reported by Nelson *et al.* (1953) and that presented herein may be in the quantity of "fines" present. Thus, the care taken to insure a minimum of "fines" in the crumbles used in the present trials may have influenced the results.

The pelleting of pig starter significantly reduced the feed required per pound of gain. This is in agreement with the results of several experiments involving pigs of various ages and weights as reported by Schneider and Brugmann (1950), Dinusson *et al.* (1951), Keith and Lehrer (1953), Thomas and Flower (1953), Steffen (1954), and Chas. Pfizer and Co., Inc. (1953). Feed wastage on the meal form of the starter did not appear to be excessive, although some wastage was evident. Feed wastage was also observed where sugar-coated pellets were fed.

Theoretically, a 20 percent sugar-coated starter should be as efficient in producing gains as a pellet containing 20 percent sugar inside. Although other factors may be involved, feed wastage is suggested as the primary cause of the difference in apparent feed efficiency.

Experience to date indicates that it is difficult to pellet a starter with over 15 percent sugar; therefore, present mechanical limitations may restrict the amount of sugar that can be included in pig starters.

The fact that early gains and feed consumption of the baby pigs were stimulated by the inclusion of sugar, indicates that sugar is most beneficial during the early part of the starting period, namely, from 1 to 5 weeks of age.

The use of sugar in pig starters may appear uneconomical, but baby pigs are very efficient feed converters, requiring only 1.5 to 2.0 lb. of

feed per pound of body gain. Also, it is very important to get baby pigs started on dry pig starter at the earliest possible age.

Pig performance was excellent, weights ranging from 52.8 to 65.7 lb. at 8 weeks of age in all experiments, except in experiment 599 where a higher disease level was encountered.

Mortality in all experiments was low, except in experiment 599 in which 6 of the 72 pigs started on experiment died.

These are believed to be the first reported palatability studies in which there has been a definite attempt to control the variations in quantity and quality of milk consumption, and to control feeder and place preference when studying the baby pig's preference to pig starters.

Summary

Three experiments involving 328 baby pigs were conducted to study the influence of cane sugar and form of pig starter on palatability, feed conversion, rate of gain and early starter consumption. Experiments were designed to control variations in quantity and quality of milk consumption as well as feeder and place preference.

In all preference studies where two or more starters were offered simultaneously, the baby pigs selected starters containing sugar. Pellets containing high levels (20 percent) of sugar were preferred, and, in all but one test, pellets with the sugar inside were preferred to sugar-coated pellets.

The level of oat groats, in the presence of 15 percent sugar, did not appear to influence palatability since nearly the same amounts of starter containing no oat groats were consumed as starters containing 40 percent oat groats.

Sugar in starters in either the meal or pelleted form significantly improved feed efficiency. Pelleting alone also significantly improved feed efficiency.

The addition of sugar within the pelleted starter significantly increased early gains and early starter consumption.

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EFFECT OF CHLORTETRACYCLINE SUPPLEMENTATION ON GROWTH AND FEED UTILIZATION OF UNSUCKLED BABY PIGS OBTAINED BY HYSTERECTOMY [1, 2]

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THE growth-promoting effect of antibiotic supplementation for swine reared under ordinary hog production programs has been amply demonstrated since 1950.

Speer *et al.* (1950) reported one experiment in which chlortetracycline (Aureomycin) supplementation failed to increase weight gains or feed utilization of weanling pigs reared under "healthy" conditions. These workers interpreted the results as substantiating the "disease level" theory of the action of antibiotics. This theory implies that antibiotics fed to unthrifty swine in unsanitary quarters reduce the "disease level," permitting animals to make greater gains under lessened environmental handicaps.

Chicks reared in new or "clean" quarters failed to show growth responses when fed antibiotics (Coates *et al.*, 1951; Lillie *et al.*, 1953; Hill *et al.*, 1953). Workers at the Lobund Institute of Notre Dame first reported that germ-free chicks and poults failed to show growth responses when fed antibiotics (Luckey, 1952), but later work showed sporadic growth responses for both germ-free chicks and poults fed antibiotics (Luckey, 1955).

The study reported here was undertaken to determine whether young swine would show growth responses and increased feed utilization upon antibiotic supplementation when reared in a carefully controlled environment following birth by the hysterectomy procedure developed at this laboratory (Young *et al.*, 1951, 1955). Inasmuch as these pigs do not receive colostrum, never contact the sow, and do not contact other pigs until moved to larger quarters, they are considered relatively "disease-free." The pigs are not sterile, but develop their initial microflora independent of the presence of other swine. The primary source of the initial microflora is pasteurized homogenized cow's milk. These condi-

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[2] With the technical assistance of Egis L. Warmanen.

[3] Austin.

tions offer for the study of antibiotic supplementation a unique experimental animal free of the usual swine diseases.

Experimental Procedure

The Chester White pigs used in these experiments were obtained through the hysterectomy procedure and reared without access to colostrum or serum globulin fractions. Upon hysterectomy, the baby pigs

TABLE 1. SOLID PRECREEP RATIONS [a] NO. 4 AND NO. 5A [b]

Ingredient	lb.	Added vitamins	Amount
	Ration No. 4		
Spray dried skim milk	45	Vitamin A	2,000,000 USP units
Dextrose	18	Vitamin D_2	200,000 I. U.
Sucrose	4	Choline chloride	45 g.
Dehulled soybean oil meal	15	Nicotinic acid	2 g.
Dried fish solubles	2.5	Alpha tocopherol acetate	350 mg.
Dried whole egg	4	Vitamin K (Menadione)	100 mg.
Distillers' dried solubles	2	Ascorbic acid	100 mg.
Torula yeast	1	Para-aminobenzoic acid	500 mg.
Dried whey product (low lactose)	2	Vitamin B_{12}	3 mg.
Lard	5.5	Thiamine•HCl	500 mg.
Lecithin	2.5	Pyridoxine•HCl	100 mg.
Ground limestone	1	Riboflavin	400 mg.
Dicalcium phosphate	0.5	Calcium pantothenate	1000 mg.
Iodized salt	0.5	Folic acid	100 mg.
Trace minerals (Limecrest delamix)	0.2	Inositol	5000 mg.
Total	103.7		

[a] Mixed to special formula by Chemical Foods, Inc., Mason City, Iowa, through the courtesy of Mr. John Tailor.
[b] Ration No. 5A is Ration No. 4 + 200 p.p.m. chlortetracycline.

were placed in individual isolation units (Young and Underdahl, 1953) and fed a diet consisting of one quart of homogenized milk, one egg yolk, 400 I.U. of vitamin D, 1 mg. of Klotogen F [4] and 5 ml. of mineral mix "B".[5]

Experiments 1 through 4 were conducted as part of a study of the effect of chlortetracycline supplementation on intestinal microflora (Larson and Hill, 1955); feeding and management practices were varied somewhat from one trial to another (table 2). The baby pigs were

[4] Klotogen F (menadione sodium bisulfite) was kindly supplied by Abbott Laboratories through the courtesy of Dr. D. V. Frost.
[5] Mineral mix "B" consisted of 49.9 g. $FeSO_4 \cdot 7H_2O$, 3.9 g. $CuSO_4 \cdot 5H_2O$, 3.6 g. $MnCl_2 \cdot 4H_2O$, 0.26 g. KI and 4.0 ml. conc. HCl per liter.

started in isolation units and at 5 to 25 days of age either transferred to individual wire-bottom cages or put into concrete-floor pens. Littermate pigs were used in each experiment; birth weights were equalized as nearly as possible. In experiments 2, 3, and 4, a special commercial creep feed [6] that contained no antibiotic was fed. Chlortetracycline supplementation was started at 21, 28, and 42 days of age in experiments 1, 2, and 3 respectively, and at birth in all succeeding experiments. The antibiotic was added to the milk of the test groups throughout the experimental periods except in experiment 4 in which it was added to a dry pig starter (Larson and Hill, 1955) after milk was discontinued at 56 days of age.

Management and feeding practices were uniform for the remaining 8 experiments (5 through 12). Pigs in those experiments were kept in isolation units until approximately 24 days of age and then transferred to concrete-floor pens. All pigs were first fed the modified cow's milk diet, the solid pre-creep ration no. 4 (table 1) being avaliable from the seventh day until the pigs were transferred to the barn. The chlortetracycline was added to the milk at a level of 10 p.p.m. of dry matter for the test groups. When the pigs were moved to the barn at 24 days, the milk was discontinued. Ration no. 4 was fed to the control group and ration no. 5A (table 1) was fed to the test group. The test groups received 200 p.p.m. chlortetracycline after 24 days of age. At 6 weeks of age a starter-grower ration [7] was mixed with the solid pre-creep diet until at 7 weeks the entire diet was the starter-grower ration. Feed consumption records were kept for all experiments except 1 and 2.

Results and Discussion

The results of experiments 1 through 4 are shown in table 2. Average daily gains were greater for the chlortetracycline-supplemented swine as compared to the controls in experiments 2, 3, and 4. Thirteen of the 15 pigs fed supplemented diets in the first four experiments made greater weight gains than the controls. In experiments 3 and 4, in which feed records were kept, the supplemented pigs showed better feed utilization. The data for these first four experiments were not analyzed statistically because of the variation in age of the pigs on test from one trial to another. The microflora of these pigs (Larson and Hill, 1955) showed considerable variation; however, the only marked difference

[6] Prepared by Nutrena Mills, Inc., Minn., through the courtesy of Dr. Wesley Nelson.

[7] The starter-grower ration was composed of the following (lb.): ground yellow corn, 60; ground oats, 10; soybean oil meal, 10; tankage, 10; fishmeal, 5; 20 percent dehydrated alfalfa leaf meal, 5; trace-mineralized salt, 0.5. Irradiated yeast (type 9-F), was added at the rate of ¼ lb. per ton.

TABLE 2. EFFECT OF CHLORTETRACYCLINE SUPPLEMENTATION ON GROWTH AND FEED UTILIZATION OF PIGS OBTAINED BY HYSTERECTOMY AND STARTED IN ISOLATION UNITS

Exp. No.	Treatment	No. of pigs	Supplementation started Age in days	Av. starting weight lb.	Days on trial	Av. final weight lb.	Av. daily gain lb.	Lb. feed per lb. gain
1 [a]	Control	2	21	6.35	35	18.05	0.33	....
	Supplemented [e]	2	21	6.75	35	18.30	0.33	....
2 [b]	Control	4	28	6.38	42	21.90	0.37	....
	Supplemented [f]	4	28	6.10	42	25.65	0.46	....
3 [c]	Control	4	42	16.95	49	56.88	0.82	2.14
	Supplemented [f]	4	42	18.30	49	69.20	1.04	2.06
4 [d]	Control	5	0	2.7	88	58.75	0.64	2.29
	Supplemented [f]	5	0	2.7	88	70.20	0.77	1.85

[a] Transferred to individual wire-bottom cages at 5 days of age and fed modified cow's milk diet throughout experiment.

[b] Transferred to individual wire-bottom cages at 16 days of age and fed commercial canned milk with added minerals. Supplemental special commercial creep feed fed with milk after five weeks of age.

[c] Transferred to individual wire-bottom cages at 25 days of age and transferred to concrete floor pens at 66 days of age. Pigs fed modified cow's milk diet with special commercial creep feed given in addition to milk at 5 weeks of age.

[d] Transferred to concrete floor pens at 24 days of age. Pigs fed as in Exp. 3 except no milk given after 56 days. Chlortetracycline was added to dry pig starter after 56 days.

[e] Chlortetracycline added at level of 5 p.p.m. on dry matter basis.

[f] Chlortetracycline added at level of 10 p.p.m. on dry matter basis.

related to treatment was a reduction of Clostridia within the ileum of the intestinal tract of the supplemented pigs.

The data for the last eight experiments are summarized collectively in table 3. Management and feeding practices were alike in all trials,

TABLE 3. EFFECT OF CHLORTETRACYCLINE SUPPLEMENTATION ON GROWTH AND FEED UTILIZATION OF CHESTER WHITE PIGS OBTAINED BY HYSTERECTOMY

Experimental interval	Comparisons	Control group	Supplemented group [a]
	Number of trials (Expts. 5–12)	8	8
	Total number of pigs	41	47
Brooder period: Baby pigs reared in laboratory isolation (0–24 days).	Average number of days in brooders	23.9	23.9
	Average initial weight (lb.)	2.69	2.70
	Average final weight (lb.)	9.43	10.15
	Average daily gain (lb.)	0.283	0.313 [b]
Pigs moved to hog barn when removed from laboratory brooders (0–56 days).	Total number of pigs	40 [c]	47
	Average 56 day weight (lb.)	27.07	31.23
	Average daily gain (lb.)	0.44	0.51 [d]
	Average lb. feed/lb. gain	2.34	2.00 [e]

[a] Chlortetracycline added to milk (0 to 3 weeks) at level of 10 p.p.m. of solids and added to pre-creep ration at level of 200 p.p.m.

[b] $P < 0.01$.

[c] One pig sacrificed at 41 days because of extremely poor growth.

[d] $P < 0.001$.

[e] $P < 0.07$.

the only difference being the chlortetracycline supplementation of 47 of the 88 baby pigs.

The greater average daily gains of the supplemented pigs for the 0- to 56-day period were highly significant ($P < .001$). In all eight trials the average daily gains were greater for the supplemented groups. In six of the eight trials the supplemented pigs showed better feed utilization. This, together with the better feed utilization of the supplemented pigs in trials 3 and 4, indicates a real advantage for chlortetracycline supplementation.

There were a few mild cases of diarrhea of undetermined origin after the pigs were moved to the hog barn. Therefore, weight gains were compared for the period of 0 to approximately 24 days, during which time the baby pigs were held in isolation units and definitely known to be free of diarrhea or any other symptoms of swine disease or intestinal upset. These data are shown in table 3 under the "brooder period." While the advantage in weight gains for the supplemented pigs was not great, it was highly significant ($P < .01$). In seven of the eight experiments, the average daily gains up to 24 days were greater for the supplemented groups.

These data establish an increased weight gain for chlortetracycline-supplemented baby pigs reared in isolation and in the absence of recognizable swine disease. In this respect we differ from the view taken by Speer *et al.* (1950). The fact that antibiotic-fed baby pigs under the conditions of our experiments do show increased weight gains and increased feed utilization indicates an effect of antibiotics in addition to that of lowering the "disease level." The heretofore recognized effect of antibiotics might well be a combination of the effect upon the intestinal microflora and protection from disease.

Summary

Twelve experiments were conducted with baby pigs taken by hysterectomy and reared in isolation; approximately half of the pigs were supplemented with chlortetracycline.

Three of the first four experiments (13 out of 15 supplemented baby pigs) showed greater weight gains for the pigs supplemented with 10 p.p.m. chlortetracycline.

In all of the eight additional experiments conducted from 0 to 56 days, the chlortetracycline-supplemented pigs (10 p.p.m. up to 3 weeks, 200 p.p.m. from 3 to 8 weeks) showed greater average daily gains. Feed utilization appeared to be better in supplemented pigs.

Baby pigs held in isolation units to 24 days of age showed better average daily gains when receiving daily supplements of 10 p.p.m. chlortetracycline. These data indicate that chlortetracycline exerts a growth-promoting effect in the absence of recognized swine disease, and has a growth-promoting effect in addition to that of lowering "disease level."

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SOME EFFECTS OF FEEDING CHLORTETRACYCLINE UPON THE CARCASS CHARACTERISTICS AND THE BODY COMPOSITION OF SWINE AND A SCHEME FOR THE RESOLUTION OF THE BODY COMPOSITION [1, 2]

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SINCE Bowland *et al.* (1951) first reported that the feeding of rations containing antibiotics impaired the carcass quality by increasing fat deposition in swine, much additional study has been made of this effect. Nevertheless, it still remains to be a controversial issue.

In an extensive study of the influence of vitamin B_{12}, cobalt and antibiotics on the composition of pork, Kline *et al.* (1952) found no significant difference in the nitrogen, fat and water contents of tissues nor in the specific gravity of the carcasses of antibiotic-fed and control pigs. Perry and Beeson (1952) made direct analysis of the carcasses of control and antibiotic-fed pigs and reported that the antibiotic-fed pigs contained significantly more fat and less protein and moisture than the control pigs. Huang and McCay (1953) observed that antibiotic-fed pigs which had gained at a significantly faster rate than their controls, yielded more total fat and lean meat by weight on gross analysis, though a lower ratio of lean to fat, than the controls. As a result of studies in which various levels of protein were fed with and without antibiotics, Robison *et al.* (1952) and Wilson *et al.* (1953) reported that antibiotic-fed pigs had a higher percentage of lean cuts. On the other hand, Catron *et al.* (1952) found no difference between antibiotic-fed and control pigs in the percentage of lean cuts.

Recently reported studies indicate that the water content might be measured in the live, intact animal. Soberman *et al.* (1949) suggested a method for this purpose based upon the use of antipyrine as an indicator in a dilution technique. The results of this procedure were compared with body water values determined by the specific gravity of

[1] From a portion of a thesis presented by A. J. Clawson to the Graduate School, Cornell University, in partial fulfillment of the requirements for the Ph.D. degree, 1955.

[2] These studies were supported in part by a grant from Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y.

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cattle and swine carcasses (Kraybill *et al.*, 1951, 1952). Wellington *et al.* (1954) found that the body water content of cattle derived by the indirect method compared favorably with that determined by slaughter and direct analysis.

Because of the discordant reports of the influence of antibiotics upon carcass quality and the developments suggesting that the measurement of body water is feasible, the objectives of the present studies were: (1) To determine the effect of feeding an antibiotic chlortetracycline (Aureomycin) on the composition of the carcasses produced, (2) to determine whether or not the body composition of swine can be resolved from a knowledge of the water content, (3) to study the degree of accuracy with which the antipyrine technique can be applied in feeding experiments with swine, and (4) to study the relationship between carcass specific gravity and body composition.

Experimental Procedure

Weanling Chester White, Berkshire and Yorkshire pigs averaging 50 lb. in body weight were divided into four lots (two replications) in such a manner that litter mates and breeds were represented equally in each of two treatments. The basal ration[5] had the following percentage composition: Ground corn, 65.0; soybean oil meal, 15.5; meat scraps, 14.0; ground alfalfa, 5.0 and iodized salt, 0.5. Aurofac[5] was added to the rations of two of the four lots at the level of 0.5 percent. As the pigs matured, the level of protein in the ration was reduced accordingly.

Randomly selected animals representing each breed and treatment were slaughtered for various carcass measurements and analyses. When each pig reached a liveweight of approximately 215 lb., body water determinations were made by the antipyrine technique (Soberman *et al.*, 1949) and the pig was slaughtered for direct analysis of the water content of the whole body. All blood and empty viscera were weighed and sampled for moisture analysis. In order to obtain representative samples, the right half of each carcass was skinned, boned and divided into three groups: fat trim and skin, carcass meat, and bone. Each of these groups was ground and sampled for the moisture analysis. Moisture determinations were made by toluene distillation. In the calculation of the total body water content, the moisture loss occurring during a 48-hour chilling period and during the boning and grinding of the carcass was accounted for by weighing the various parts. The left half of each carcass was used for carcass measurements and for the determination of specific gravity.

[5] Supplemented with Fortafeed 2–49C, Research Division, American Cyanamid Company, Pearl River, N. Y., who also supplied the Aurofac.

TABLE 1. SUMMARY OF NUMBER OF PIGS USED AND THEIR WEIGHTS, GAINS AND DRESSING PERCENTAGES

Groups	No. of pigs	Av. initial weight	Av. gain	Slaughter weight	Warm carcass weight	Dressing percentage
		lb.	lb./day	lb.	lb.	
Treatment						
Control	11	51.5	1.25	211	178	85
Antibiotic-fed	11	48.6	1.32	221	188	85
Breed						
Chester White	8	54.0	1.39	226	192	85
Berkshire	8	44.5	1.32	214	180	84
Yorkshire	6	52.0	1.13	204	174	85

Results and Discussions

Growth and Slaughter Data

The growth and slaughter data obtained in this experiment are summarized in table 1. The final weights were governed, to some extent, by the slaughter schedule. As will be noted, the antibiotic-fed pigs made slightly (non significant) greater average gains and were slaughtered at heavier weights than the control pigs. In this trial, the Chester White pigs tended to gain faster and reached slaughter weights in fewer days than the other two breeds.

Wholesale Cuts

The percentages of the whole-carcass weight constituted by the wholesale cuts are shown in table 2. As a result of adjusting the total weights of the hams and bellies to an equal slaughter weight by use of covariance

TABLE 2. PROPORTIONS OF CARCASS CONSTITUTED BY WHOLESALE CUTS

Groups	Percentage of carcass as wholesale cuts				
	Ham	Loin	Shoulder	Belly	Lean cuts
Treatment					
Control	17.4	13.6	15.7	13.2	46.6
Antibiotic-fed	17.3	13.7	16.2	13.8	47.2
Breed					
Chester White	17.0	12.2	15.0	14.9	44.2
Berkshire	17.0	14.4	16.2	12.8	47.6
Yorkshire	18.4	14.8	17.0	12.4	50.1

analysis, it was found that no significant differences exist either between the treatments or among the breeds involved. However, the Yorkshire pigs tended to have a higher proportion of lean cuts than the other breeds, particularly the Chester Whites.

Physical and Chemical Composition of Carcass

The average total weights of carcass meat, fat trim and bone from the carcasses and the percentages of moisture and fat in the carcass meat are presented in table 3. The slightly greater amounts of the three tissue groups of the antibiotic-fed pigs reflect the larger body size of this group at slaughter time. The greatest difference found is that in the weight of

TABLE 3. WEIGHTS OF TISSUE GROUPS AND THE WATER AND FAT CONTENTS OF CARCASS MEAT

Groups	Tissue groups [a]			Carcass meat [b]	
	Carcass meat	Fat trim	Bone	Water	Ether extract
	lb.	lb.	lb.	%	%
Treatment					
Control	100.2	48.6	22.6	51.8	33.5
Antibiotic-fed	105.6	50.2	24.0	50.6	34.8
Breed					
Chester White	100.4	61.0	23.8	50.2	35.1
Berkshire	104.6	46.2	22.6	51.4	33.8
Yorkshire	103.8	38.4	23.6	52.4	32.4

[a] Weights determined on half carcasses computed to whole-carcass basis.
[b] Water and fat contents determined directly.

fat trim. Yorkshire pigs tended to be least wasty in this respect. Both the Yorkshire and Berkshire pigs yielded more carcass meat and less fat trim than the Chester Whites, even though they weighed less at the time of slaughter. Also, the carcass meat of the Yorkshire and Berkshire pigs contained less of ether extractable fat (table 3).

Determination of Total Body Water Content by Use of Antipyrine Method

A study was made of the accuracy with which the water content of the total body of swine can be determined by use of the antipyrine method. The values obtained with the indirect procedure are compared in table 4 with those determined directly by analyzing representative

samples of the whole, empty body. Twenty-nine pigs (twenty-two of which were employed in the experiment dealing with the feeding of chlortetracycline) were used in these comparisons. The average difference between the water contents determined by the two methods was 2.4 percent. For 9 pigs, the antipyrine method gave percentages of body water greater than those found by direct analysis; whereas, the estimate for 20 animals was lower than that measured directly. The correlation coefficient between the water contents measured by use of the two methods was 0.78. The correlation might have been higher had a range in water content wider than that (38 to 59 percent) observed in this experiment been studied. A faster rate (55 percent per hour) of metabolism of the injected antipyrine was observed in this experiment than that (35 percent per hour) reported by Kraybill *et al.* (1953).

TABLE 4. COMPARISON OF WATER CONTENT OF WHOLE EMPTY BODIES DETERMINED BY ANTIPYRINE METHOD WITH THOSE MEASURED DIRECTLY

Method of determination	Water content (%)	
	Mean ± st'd. dev.	Range
Direct	45.5 ± 4.0	37.9 — 59.3
Antipyrine	44.4 ± 4.6	36.7 — 59.1

Although the accuracy with which the water content of individual pigs can be estimated with the indirect method is less than that desired, this procedure would appear to be satisfactory when applied in experiments involving sufficient numbers of animals. It has obvious advantages over the direct slaughter-analysis technique in that it can be applied to the same individuals at both the beginning and end of the feeding period, and it is less expensive.

Prediction of Water Content of Carcass and Whole Body from Specific Gravity

The correlation coefficient, 0.89, was computed between the specific gravity and water content of the carcass. The relationship between these two variables is expressed by the equation: $\hat{Y} = 418.58\ X - 393.31$; where $\hat{Y}$ = Water content of carcass (percent) and X = Specific gravity of the carcass. The standard deviation from regression is 1.93 percent water. The correlation between the specific gravity of the carcass and the total body water content was 0.63. This coefficient is considerably lower than that found between the same characteristics of the carcass.

These observations suggest that the variable water content of the viscera found between pigs makes the prediction of the water content of the whole body from the carcass specific gravity questionable. Kraybill *et al.* (1953) obtained a close agreement between the fat content of the body derived from the antipyrine method and that determined by tissue separation and by the specific gravity method. In computing body fat from the water content determined by the antipyrine method, these workers assumed that the water content of the fat-free body is 74.4 percent.

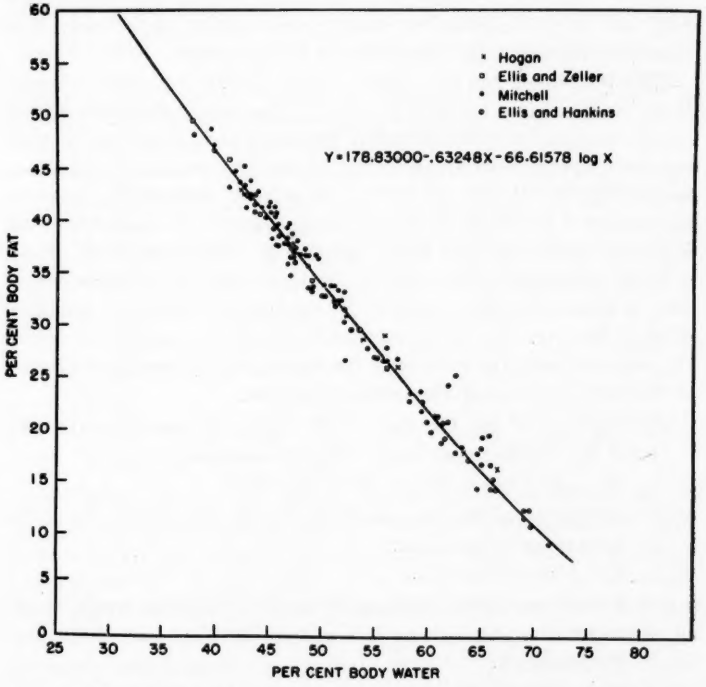

Figure 1. The relationship between the water and fat contents of the whole, empty body of swine.

Resolution of the Chemical Composition of the Whole Body of Swine

Since certain relationships are known to exist among the chemical components of the body of animals (Reid *et al.*, 1955) and since indirect methods for the measurement of body water seem promising, a study

was made to determine whether the composition of the body of live swine could be resolved. An examination of the data published on the chemical composition of the whole, empty bodies of 127 pigs ranging in weight from 10 to 350 lb. and in age from 26 to 300 days, by Ellis and Hankins (1925), Ellis and Zeller (1939), Mitchell and Hamilton (1925) and Hogan *et al.* (1925) revealed that the percentages of water and fat are highly correlated inversely ($r = 0.98$). This relationship (figure 1) was found to be curvilinear (deviation from linearity, highly significant) and may be expressed by the equation: $\hat{Y} = 178.83 - 0.63\ X - 66.62 \log X$; where, $\hat{Y}$ = Percentage of fat in the whole, empty body and X = Percentage of water in the whole, empty body. The standard deviation from regression is 1.4 percent fat.

Since the protein and ash contents of the fat-free, dry matter of cattle is relatively constant (Reid *et al.*, 1955), these components were studied on this basis in the bodies of swine. The mean protein and ash contents and their standard deviations in the fat-free, dry matter of swine were found to be 83.1 ± 1.6 and 16.9 ± 1.6 percent, respectively. In swine, the amount of protein is about 3 percentage units higher and that of ash is about 3 percentage units lower than that of cattle (Reid *et al.*, 1955).

These data suggest that, when the water content of the whole, empty body is known, the percentages of fat, protein and ash can be predicted quite accurately. The above relationships make it possible to resolve the composition of the body from the water content (measured directly or indirectly) by use of the following scheme:

(1) Estimate of the fat content ($\hat{Y}$) from the water content (X) of the whole, empty body using the equation:
$\hat{Y} = 178.83 - 0.63\ X - 66.62\ \log\ X.$

(2) Estimation of the percentages of fat-free, dry matter (Z) in the body using the equation:
$Z = 100 - (\hat{Y} + X).$

(3) Estimation of the percentage of protein (P) in the whole, empty body:
$P = 83.1\ (Z).$

(4) Estimation of the percentages of ash (A) in the whole, empty body:
$A = 16.9\ (Z).$

Very little carbohydrate is present in the animal body and its caloric value is not greatly different from that of protein. Since, in this procedure, any carbohydrate in the body would be included in the protein "fraction" and since the caloric values of protein and fat are well estab-

lished, it is possible to extend this procedure to an estimation of the energy value of swine bodies. Measurement of the water contents of pigs at the beginning and end of a feeding period would allow the change in energy value of the body to be determined. As a consequence, this approach would provide a net evaluation of the energy in swine rations.

Much attention has been given to, and much use has been made of, the relative constancy of the amounts of the components of the fat-free body of animals. For example, the fat content of "chemically" mature animals is frequently computed on the basis that the water content of the fat-free body is a value ranging generally from 71.0 to 74.4 percent. Although a mean value of 72.9 percent was found in cattle, the water content of the fat-free body is highly significantly correlated with the

TABLE 5. INFLUENCE OF VARYING AMOUNTS OF WATER AND FAT IN THE WHOLE BODY UPON THE COMPOSITION OF THE FAT-FREE BODY

Whole, empty body basis		Fat-free body basis	
Water	Fat	Water	Protein
%	%	%	%
70	11.64	79.22	17.27
65	16.95	78.27	18.06
60	22.43	77.35	18.82
55	28.11	76.51	19.53
50	34.03	75.79	20.12
45	40.24	75.30	20.53
40	46.81	75.20	20.61
35	53.83	75.81	20.10

age of animal (Reid *et al.*, 1955). The distribution of the data for the 127 pigs studied was not adequate to study the influence of age. However, a study was made of published data already cited to determine the influence of varying water and fat contents in the whole, empty body upon the water and protein contents of the fat-free body. The data summarized in table 5 show that the use of a constant value for the water content of the fat-free body could be quite inaccurate. It was found also that the relationship between the percentages of water and fat in the whole body is practically linear when the whole body contains from 34 to 46 percent of fat. Within this range the mean moisture content of the fat-free body is 75.3 percent. Since most pigs are slaughtered at weights of about 225 lb. and, at these weights, contain from 34 to 46 percent of fat, this constant (75.3 percent) would seem to be more accurate for these conditions than the others which have been employed.

Estimated Composition of Whole Bodies of Pigs in Antibiotic-Feeding Experiment

In view of the high degree of accuracy with which the major chemical components of the bodies of swine may be predicted from a knowledge of the water content, the proximate composition of the pigs employed in the antibiotic-feeding experiment was computed. These data are recorded in table 6. The use of covariance analysis for adjusting all data to an equal slaughter-weight basis revealed no statistically significant differences in the percentages of fat or protein either between the two treatments (antibiotic and control) or among the three breeds involved.

TABLE 6. FAT, PROTEIN AND ASH CONTENTS OF THE WHOLE, EMPTY BODY ESTIMATED FROM THE WATER CONTENT

Groups	Chemical composition (%)			
	Water [a]	Ether extract [b]	Protein [b]	Ash [b]
Treatment				
Control	45.8	39.2	12.5	2.4
Antibiotic-fed	44.9	40.4	12.2	2.5
Breed				
Chester White	43.5	42.2	11.9	2.5
Berkshire	46.3	38.6	12.5	2.6
Yorkshire	46.6	38.2	12.6	2.6

[a] Water content determined by direct analysis.
[b] Percentages of fat, protein and ash derived from the water content.

Summary

Some of the effects of feeding chlortetracycline upon certain carcass characteristics and the chemical composition of the body of swine were studied. The chlortetracycline-fed pigs gained weight at a slightly more rapid rate than their controls. No significant differences were found between the treatments with respect to the dressing percentage, the proportion of the whole carcass consisting of the wholesale cuts, the actual chemical composition of the carcass meat or the estimated composition of the whole, empty body. As a consequence of the antibiotic-fed pigs weighing slightly more at slaughter time, the average weights of the carcass meat, fat trim and bone from this group were a little greater than those from the control pigs.

The specific gravity of the carcass was highly correlated (0.89) with the water content of the carcass. A lower correlation (0.63) was found between the specific gravity of the carcass and the water content of the hole, empty body.

During the course of these experiments, a comparison as made between the body water contents of 29 pigs derived by use of the antipyrine-dilution technique and those determined by direct analysis. Within the range (38 to 59 percent) of water contents studied, fairly close agreement was obtained between the results of the two methods. Although the indirect method does not detect small differences in water content, it will provide reliable average results when applied to four or more pigs on a given treatment and when the differences in water content are large.

As the result of a study of data published on the body composition of 127 pigs, it was found that the water and fat contents are highly correlated (—0.98) and that the relationship between these two characteristics allows an accurate prediction of the fat content from a knowledge of the water content. The composition of the fat-free body was found to be variable; the fat-free matter of the body varies in water content inversely with the original fat content of the whole animal. The protein and ash contents of the fat-free, dry body were found to be remarkably constant (83.1 $\pm$ 1.6 and 16.9 $\pm$ 1.6 percent, respectively). Based upon these relationships, a procedure was outlined whereby the total composition of the body of swine can be resolved and the energy value of the body computed from a knowledge of the water content of the whole, empty body.

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THE GROWTH CURVE OF PIGS BETWEEN 134 AND 174 DAYS OF AGE[1]

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MOST workers have found that the growth curve of pigs was approximately linear over the period centered around 180 days of age. In these studies the pigs were approaching a weight of 160 to 200 lb. Bywaters and Willham (1935) found that a tangent fitted to the growth curve at 180 days intercepted the age axis at approximately 65 days. Whatley (1937) summarized the results of several studies and obtained an average age axis intercept of 60 days. Lush and Kincaid (1943) used a quadratic equation to describe the growth of pigs at the earlier age of 154 days. Their study was based on a growth curve, published by the Larrowe Milling Company (1941), which did not reach the point of inflection at that age. Correction methods developed from these studies have been used extensively for adjusting the weights of pigs to standard ages of 180 days or 154 days. Such adjustments are convenient in weighing groups of pigs of mixed ages. Indeed, weighing such groups only once or twice and adjusting to a constant age may be more accurate than weighing on the exact date, since the former method would minimize the disturbing influence occasioned by taking repeated weights in groups of mixed ages.

More recently, improvements in breeding, feeding and management appear to have caused sharp increases in growth rate. It seems logical that this increase would cause a shift in the growth curve, the linear period of growth occurring at an earlier age, although valid evidence on this point is not available. Because of the wide use made of correction factors centered around 154 days, the present study was designed to examine the growth curve immediately prior to and after this period. The accuracy of several possible correction factors which might be useful in adjusting the weights to 154 days of age was also examined.

Experimental

The weights of 255 pigs were taken at 134, 144, 154, 164 and 174 days during the summer of 1953. The pigs were in four alfalfa-brome

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pasture lots, each lot containing about 60 pigs of the same age. In order to minimize the effects of changes in weather, the weighing days were arranged so that no two lots were weighed on the same day. The pigs were self-fed from weaning to market weight on shelled corn and a 35 percent fortified protein supplement. The pigs were of mixed breeding, mostly crossbreds consisting of Landrace, Duroc, Poland China, and Chester White breeding. There were 71 barrows and 184 gilts in the study.

Results

The average weight at each age is shown for each of the four lots in table 1. Standard deviations and coefficients of variability are given for the entire group. The average growth curve from 134 to 174 days is

TABLE 1. AVERAGE WEIGHT OF 255 PIGS BY AGES AND LOTS

Lot	Age in days				
	134	144	154	164	174
	lb.	lb.	lb.	lb.	lb.
1	133.7	151.8	167.5	187.2	204.1
2	138.9	154.0	171.5	182.8	197.6
3	146.2	163.1	180.0	197.9	214.9
4	134.6	153.3	167.3	185.1	199.9
Mean	138.1	155.3	171.4	188.2	204.1
Standard deviation	19.1	19.8	20.7	21.7	23.2
Coefficient of variability	13.8	12.7	12.1	11.6	11.4

illustrated in figure 1. This curve is evidently linear over the period from 134 to 174 days, the average daily gain for all pigs being 1.65 lb. per day.

In order to examine the linearity of growth of rapid-gaining as compared with slow-gaining pigs, the data were sorted into a high third and a low third based on the weight at 154 days. The averages for these two groups are also plotted in figure 1. Evidently here also the growth is linear for both the heavier and the lighter group. The heavier pigs gained 1.72 lb. per day while the lighter ones gained 1.52 lb.

The requisites of a satisfactory correction factor to adjust for differences in age when the pigs were weighed may be listed as follows: (1) The method must be accurate in the sense that adjusted weights agree as closely as possible with the actual weights at 154 days. From figure 1, a formula which allowed for linear growth as a function of the weight at the age weighed appears a logical starting point. (2) The variance of adjusted weights should be approximately equal to the

variance of actual 154 day weights. (3) It must be convenient for practical application.

The following methods were examined with reference to the above requirements:

Method 1 was the quadratic equation developed by Lush and Kincaid (1943). It overestimated the 154 day weights of the present pigs when they were adjusted to 154 days from 134 and 144 days while it underestimated them when they were adjusted from 164 and 174 days. The

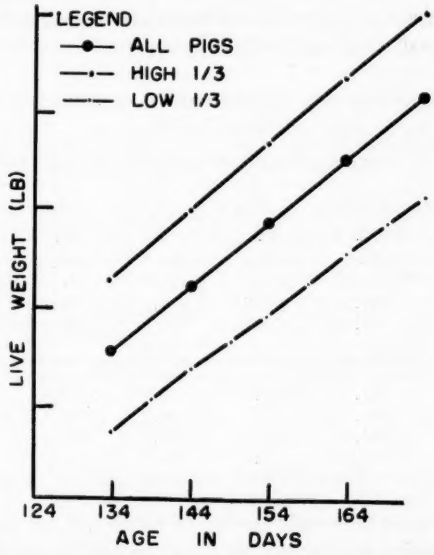

Figure 1. Average growth curves for different groups of pigs.

variances of the estimated weights were greater than actual when estimated from the younger ages and were smaller than actual when estimated from the older ages. As shown in table 2, the discrepancies for both means and variances were more extreme at the extreme ages. Since the discrepancies are in opposite directions on each side of 154 days, this method is quite accurate only when two equidistant weights can be averaged.

Method 2 was the strictly linear method of adding or subtracting 1.65 lb. per day for the number of days by which the pigs were younger or older than 154 days. The average adjusted weights corresponded closely

the actual 154 day weights but their variances were smaller than the actual 154 day variance when adjustments were made from younger ages and greater when adjustments were made from older ages (table 2). This latter discrepancy was largely a consequence of the heavier pigs gaining more rapidly than the lighter pigs as illustrated in figure 1.

Method 3 was developed by using the ratio of the average 154-day weight to the average weight at other ages. The ratio for any given age was multiplied by the weight at that age to adjust to 154 days. As shown in table 2, the adjusted means agreed closely with the actual means but the variances were too large when adjustments were made from younger ages and too small when made from older ages.

TABLE 2. MEANS AND VARIANCES OF WEIGHTS ADJUSTED TO 154 DAYS

Age	Means of 5 methods (actual 154 day mean, 171.4 lb.)				
	1	2	3	4	5
	lb.	lb.	lb.	lb.	lb.
134	175.1	170.2	171.0	170.1	170.8
144	174.1	171.3	171.3	171.3	171.6
164	169.2	170.6	171.2	171.7	171.0
174	165.9	171.1	171.0	171.8	171.4
	Variances of 5 methods (actual 154 days variance, 427.3 lb.)				
134	585.9	365.5	558.6	454.9	450.5
144	491.2	389.4	476.3	432.5	432.5
164	382.6	472.0	392.3	432.7	429.1
174	358.0	538.7	376.7	454.7	444.9

Method 4 was an arithmetic average of methods 2 and 3. This method appeared promising because the discrepancies noted in methods 2 and 3 were so nearly equal but in opposite directions. Agreement between the actual and adjusted means and variances was very good, as shown in table 2.

Method 5 was developed by extrapolating 10 growth curves to a common intercept. The 255 pigs were sorted in 10 groups on the basis of weight at 154 days. The groups differed in average weight and average growth rates in a fairly regular manner so the plotted curves appeared fan shaped. The extrapolated lines tended to converge to a common point which was estimated by least squares to be — 45 days on the age axis and — 154 on the weight axis. When this point and the actual weight of the pigs at the different ages were used to predict 154 day weight the

means and variances of the adjusted weights agreed very well with the actual figures (table 2).

Method 6 was that of linear interpolation. Although this method was not studied intensively here, it is evident that it must have maximum accuracy for truly linear growth curves. One additional advantage of linear interpolation is that it permits the proportionate adjustment of two weights, depending upon their distance from the standard age. A convenient table based on varying ages can be formulated to facilitate computations. The important disadvantage of this method is that two weights are necessary for interpolation, whereas the other methods can be applied when only one weight is available.

Application

The two most satisfactory methods for general use in adjusting weights such as these to 154 day weights clearly seem to be methods 4 and 5. The results of the two differ in such minor respects and give so nearly the same answers that it appears impossible to differentiate between them on the basis of the criteria listed previously. Although developed by entirely different procedures, the multiplicative and additive factors derived for the two methods are remarkably similar (table 3).

TABLE 3. MULTIPLICATIVE AND ADDITIVE FACTORS FOR METHODS 4 AND 5 AT 134, 144, 164 AND 174 DAYS

Age	Factor	Method 4	Method 5
134	Multiplicative	1.118	1.112
	Additive	16.50	17.20
144	Multiplicative	1.053	1.053
	Additive	8.25	8.14
164	Multiplicative	0.956	0.952
	Additive	−8.25	−7.37
174	Multiplicative	0.919	0.909
	Additive	−16.50	−14.07

On the basis of general validity, method 5 appears to have preference over method 4. The concept of differing linear growth curves generated from a common point is obviously fallacious in the present case, because the growth curves must have been curvilinear shortly before the age these weights were taken. However, method 5 has certain desirable statistical properties not possessed by method 4. For example, the accuracy sacrificed by assuming a common intercept can be measured statistically.

In addition, the difference in common intercepts obtained from independent sets of data can be tested statistically.

The procedure for calculating the factors necessary for routinely using method 5 rests on the equality of the two linear regressions,

$$\frac{\text{adjusted weight} - \text{weight intercept}}{\text{standard age} - \text{age intercept}} = \frac{\text{actual weight} - \text{weight intercept}}{\text{actual age} - \text{age intercept}}$$

Here the age and weight intercepts at point of intersection are — 45 days and — 154 pounds, respectively, while the standard age is 154 days. Solution of this equation gives the adjusted weight from any actual age in terms of a factor to be multiplied by the weight at that age plus an additive factor. These are given for 134, 144, 164, and 174 days in table 3. For example, a weight of 130 lb. taken at 144 days would be multiplied by 1.053 and 8.1 lb. added to the product to give 144.9 lb. as the adjusted 154 day weight. The factors for intervening days can be calculated without difficulty.

Any method of adjusting weights which is likely to receive wide use should be tested extensively under a wide variety of conditions. Different systems of management involving self- or limited feeding, pasture or dry lot, etc., which change growth rate markedly may change the shape of the growth curve sufficiently that no one method will be suitable for all pigs. However, common intercepts of — 45 for age in days and — 154 for weight in pounds appeared to be so consistently a property of the 10 groups of pigs here which varied in rate of gain, that method 5 should be applied to other groups in an effort to assess its general usefulness.

Summary

The growth curves of 255 pigs weighed at 134, 144, 154, 164, and 174 days of age were essentially linear over this period. The growth curves varied for particular pigs, each seeming to be a linear function of the weight attained at a given age. A common intercept of — 45 days on the age axis and — 154 lb. on the weight axis fitted the data for both fast and slow-growing pigs, assuming linearity of growth over the period from 134 to 174 days.

Several possible methods of adjusting weights to a standard age (154 days) were examined. One of the most accurate and convenient was:

$$\text{Adjusted weight} = \frac{(\text{Actual weight} + 154)\ (199)}{\text{Actual age} + 45} - 154$$

Linear interpolation is also accurate and convenient when two weights on each animal are available.

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ANTIBIOTIC FEEDING FOR PROPHYLAXIS OF EXPERIMENTALLY PRODUCED SWINE ERYSIPELAS [1]

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SWINE erysipelas most frequently affects young pigs and may occur in either the acute or chronic form. It has been known to exist in the United States for over 50 years (Breed, 1942) and now appears to be a very serious problem. The acute form is characterized by a high temperature (up to 108° F.), anorexia, sometimes vomiting, infrequent defecation, and death. The chronic form results in slow growth, lameness, and occasionally death.

That trace amounts of antibiotics in swine rations have a growth stimulating effect has been shown repeatedly. However, the reason for this effect is as yet unknown. It has been postulated that the stimulation of growth is partly due to the suppression of subclinical disease or that toxin-producing organisms in the intestinal tract are inhibited or destroyed. For several years penicillin has been used for the treatment of clinical erysipelas. Aitken (1950) reports good results from its use. Gildow (1950) reported that pigs fed trace amounts of antibiotics developed no symptoms of erysipelas while previous lots in the same area had always shown symptoms of chronic erysipelas.

On the basis of these previous observations, two controlled trials were undertaken to determine how feeding trace amounts of antibiotics affects experimentally produced erysipelas.

Materials and Methods

Preliminary trials were conducted with two weanling pigs to determine the best method of inducing swine erysipelas experimentally. The pigs were inoculated with six strains of the organism *Erysipelothrix rhusiopathiae*, using the dermal scratch method reported by Fortner and Dinter (1944). Linear dermal scratches were made on the side of the pig with a semi-blunt instrument. Each of the cultures was then inocu-

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lated into a single scratch by means of a swab. Daily observations were made on the width of the scratches. For several days, both pigs had an elevated temperature and an area of dermatitis at the point of inoculation. After one week, both appeared normal. They were autopsied at 10 and 12 days, respectively, following inoculation. The autopsy disclosed acute hyperplastic lymphadenitis in the regional lymph nodes.

Experiment I

In the definitive trial, 32 weanling pigs were observed for two weeks to determine whether they were normal. During this period, repeated observations were made and one blood examination was conducted. This included erythrocyte, leukocyte, and differential counts. The pigs were found to be normal except for a slight elevation of the leukocyte count. They were divided into four equal lots considering body weight, sex, and breed. Each pig was identified by a metal ear tag. Lots were designated 1, 2, 3, and 4. Lots 1 and 2 were fed a basal mixture consisting of barley, peas, alfalfa meal, fish meal, iodized salt, bone meal, and ground limestone. Lot 3 was fed the basal ration plus 15 mg. penicillin per pound of feed. Lot 4 was fed the basal ration plus 15 mg. oxytetracycline (Terramycin) per pound of feed. The pigs were self-fed. Water was available continuously.

After two weeks on the rations, the pigs in lots 2, 3, and 4 were exposed by the dermal scratch method to a mixed culture of the three most virulent strains of the organism. Beginning 24 hours after inoculation, temperatures were taken at daily intervals for eight days, and the pigs were observed carefully. Two weeks after inoculation, two pigs of lots 2, 3, and 4 were sacrificed and examined for gross and microscopic lesions. At 2-week intervals thereafter, two pigs from each of the four lots were sacrificed. At the 8-week period, the other two pigs in lot 1 were sacrificed along with the remainder of the pigs.

Experiment II

The second trial was of a replicated 2×2 factorial design and was set up using 40 weanling pigs. The pigs were divided into eight equal lots of five each, considering body weight, sex, type, and were numbered according to lots. Of the 8 lots of pigs, 4 were isolated and 4 were not. All 8 lots received the same basal ration fed in Experiment I. Two lots of isolated and two unisolated received dibenzylethyllenediamine penicillin G (assay 1200 units per mg.) at the rate of 40 mg. per pound of feed. Twenty-five days after the pigs were placed on the rations, the isolated lots were challenged by the dermal scratch method.

For a time following inoculation, the temperature and condition of the pigs were observed closely. All of the pigs were kept on the experiment until they reached market weight instead of being sacrificed at intervals as in the first trial. This was done to determine whether or not greater weight gain differences would be observed with infected pigs than with uninfected pigs when penicillin was fed.

In both trials all of the abdominal and thoracic organs of the pigs were examined closely during autopsy. Sections for microscopic observations were taken from the heart valves, lungs, liver, spleen, kidney, and regional lymph nodes. A piece of the spleen and at least one regional lymph node was collected aseptically for cultural examination.

Results

Twenty-four hours after inoculation, the pigs in lots 2, 3, and 4 of Experiment I were observed to be slightly stiff and depressed. The dermal scratches were surrounded by areas of reddening and edema. The local lesions continued to widen throughout the next five days. At four to five days, a few areas of the skin lesions were dark purple and very hard. By this time the central portion of the dermal lesion near the scratch had become nearly normal. General signs of illness were relatively slight. Elevations in temperature were observed 24 hours after inoculation and became somewhat higher about the third day. Thereafter, the temperatures gradually subsided, although occasional high temperatures were found at six or seven days after inoculation.

Table 1 gives the average width of the skin lesions at two days after inoculation and the average temperature of each of the lots at three days after inoculation. Temperature peaks were noted on the first and third days after exposure. The temperature of the lots at three days was more than one degree above the average temperature of the controls, and many temperatures in excess of 106° F. were noted.

The post mortem lesions are summarized in table 2. Endocarditis was observed occasionally, especially in the animals killed at two and four weeks after exposure. Arthritis was observed in six of the 24 pigs exposed. These lesions were slight and consisted of an increased amount of joint fluid and a reddening of the joint capsule. Lymphoid hyperplasia and inflammation were observed in all of the regional lymph nodes of the inoculated pigs. These lesions were more prominent at two weeks after inoculation and then subsided.

The cultures were uniformly negative except for one pig in lot 2 from

TABLE 1. SKIN LESIONS AND TEMPERATURES RECORDED IN EXPERIMENTALLY-PRODUCED SWINE ERYSIPELAS

Lot	Ration	Exposure to culture	Average width of skin lesion at 2 days	Average temperature 3 days after exposure
			cm.	
1	Basal	Not exposed		104.3
2	Basal	Exposed	3.90	105.4
3	Basal plus penicillin [a]	Exposed	3.72	106.0
4	Basal plus oxytetracycline [a]	Exposed	3.47	105.5

[a] Antibiotics added at level of 15 mg. per pound of feed.

which a positive culture was obtained. This culture was inoculated into mice to prove its pathogenicity.

Symptoms of lameness and joint enlargements were seen in one pig in lot 3 and one pig in lot 4. On autopsy, these pigs and several others were found to have arthritis. Non-specific lesions were observed in a few of the pigs.

There was no difference among the three groups of exposed swine in the symptoms or lesions of swine erysipelas. All groups were affected equally, and there was no significant difference in the quantitative measurements of the disease such as temperature or size of dermal lesions.

In Experiment II in which 20 out of the 40 pigs were inoculated, the severity of infection, as judged by temperature changes and dermal lesions, was very nearly the same as in the first trial. The temperatures exceeded 106° F. for several days, and the areas of the scratches became red, swollen, and firm. The pigs showed lassitude, anorexia, and slight

TABLE 2. NUMBER OF PIGS WITH POST MORTEM LESIONS

Lot (8 pigs each)	Ration	Exposure to culture	Endocarditis	Arthritis	Local lymphoid hyperplasia
1	Basal	Not exposed	0	0	0
2	Basal	Exposed	4	2	8
3	Basal plus penicillin [a]	Exposed	4	3	8
4	Basal plus terramycin [a]	Exposed	3	1	8

[a] Antibiotics added at level of 15 mg. per pound of feed.

stiffness. All of the exposed group were similar in regard to the symptoms of disease produced.

The growth curve of the exposed swine was slightly flattened for about two weeks, but there was no death. At market weight the average daily gain of the erysipelas-infected pigs was 1.51 lb., while the uninfected pigs gained 1.56 lb. daily per pig. The infected pigs required 449 and the uninfected pigs 442 lb. of feed per 100 lb. of gain. Neither of these differences was statistically significant. The pigs supplemented with penicillin gained an average of 1.62 lb., while those on a penicillin-free ration gained 1.52 lb. per pig daily. The amount of feed required per 100 pounds of gain for the penicillin-fed pigs was 440 lb. and for the non-penicillin-fed pigs 451 lb. The difference in the rate of gain was significant (P less than .05) in favor of feeding penicillin, but, the difference in feed efficiency was not statistically significant.

At the time of slaughter no lesion attributable to erysipelas infection was found.

Discussion

The transmission of swine erysipelas to pigs by the dermal scratch method (Fortner and Dinter, 1944) appears to be a very successful method of producing the disease experimentally. Most of the strains will not produce serious illness or death by this method, but the lesions produced can be observed clinically and measured. In this manner the relative degree of clinical illness can be assayed quantitatively.

The addition of antibiotics to the ration was found to be of no advantage in preventing or ameliorating experimentally-produced swine erysipelas. However, the fact that the infection was produced intracutaneously and the antibiotics were administered orally may have been a limiting factor. In natural exposure, the antibiotics taken in by mouth may have a much better chance of inhibiting infections which also may enter by way of the alimentary tract.

In Experiment I, the level of antibiotic fed in the first trial was considerably below that necessary to produce a blood level inhibitory to the organism. In Experiment II, a higher level of penicillin, almost three times that used in Experiment I, still failed to inhibit the infection. Because the pigs were sacrificed early in the first trial, the effect of the antibiotics on the body weight of the infected pigs could not be discerned. Greater emphasis was placed on this aspect during the second trial, but the results did not show a significant difference between infected and disease-free pigs.

Summary

Swine erysipelas was produced experimentally in weanling pigs by the dermal scratch method. Typical symptoms and lesions of erysipelas were shown by the pigs following inoculation with *Erysipelothrix rhusiopathiae*.

Penicillin or oxytetracycline at the rate of 15 mg. per pound of feed had no effect on the symptoms or lesions of the erysipelas-infected pigs.

Penicillin fed in a ration to pigs at a level of 40 mg. per pound of feed failed to inhibit the symptoms or lesions of erysipelas, as measured by skin changes and temperature levels. The penicillin-fed pigs gained an average of 1.62 lb. daily, while those on a penicillin-free ration gained only 1.52 lb. per pig daily. This difference was significant (P less than .05).

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MOTILITY AND FERTILITY OF SPERMATOZOA AS AFFECTED BY INCREASED AMBIENT TEMPERATURE [1]

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THE occurrence of lowered fertility in rams early in the breeding season without apparent reduction in motility of spermatozoa has been noted by Hulet *et al.* (1954). The high summer temperature has been suspected as the cause of the lowered fertility, but the most commonly made observations on the effect of heat on the testes have been on their degeneration and on the decreased quality of semen (Fukui, 1923; Moore, 1924; and Moore and Oslund, 1924). El-Sheikh and Casida (1954) showed that motility (*in vitro*) and fertility of rabbit spermatozoa are phenomena which may or may not be affected similarly by an environmental factor. Asdell and Salisbury (1941) showed that when rabbit testes were anchored in the abdomen, motility of spermatozoa ceased about the 14th day but complete sterility was shown to occur at the 9th day. They also concluded that fertility and motility are not parallel phenomena and that experimental males with live spermatozoa were sterile because the spermatozoa were not able to travel further than to the uterus and lacked the power to survive until the eggs were shed.

The present report covers an investigation of the fertility of male rabbits subjected to a certain ambient temperature and for a certain interval of time just short of the point that would cause a depression in motility during the month following treatment.

Material and Methods in Preliminary Trials

Preliminary trials were made to determine approximately the maximum ambient temperature to which male rabbits might be subjected for a relatively short period of time which would not impair their health or the motility of their spermatozoa. Mature male rabbits were used which had been on a regular semen collection schedule and which had not less

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than 60 percent of their spermatozoa showing forward motion. These animals were placed in a temperature- and humidity-controlled chamber (an electric egg incubator) for various intervals and at various temperatures. Body temperatures of the rabbits were recorded just before they were placed in the warm chamber and immediately after they were removed. Tested clinical thermometers were used. Semen was collected by the artificial vagina (Macirone and Walton, 1938) at intervals of 2 to 3 days for 4 weeks after the treatment. The semen was diluted with Krebs solution, 1 part of semen to 9 parts of diluent at room temperature. Motility of spermatozoa was checked microscopically to determine whether the treatment had an observable effect.

TABLE 1. BODY TEMPERATURE AND PERCENT OF MOTILITY OF SPERMATOZA OF TREATED RABBITS [a]

Trial No.	Incubator Temperature (°F)	Incubation period (minutes)	Body temperature (°F)		Range, % sperm showing forward motion	
			Before incubation	After incubation	Before incubation	After incubation [b]
1	120	120	102.4	109.7	60–90	0–20
2	115	30	104.3	108.8	60–70	20–70
3	113	60	104.0	111.2	70–75	died
4	113	60	104.2	111.0	70–75	died
5	110	90	104.0	111.0	60–70	died
6	110	30	103.4	109.5	55–85	60–75
7	110	60	102.0	104.8	70–75	65–75
8	110	60	105.7	109.6	75–85	75–80
9	110	60	102.0	106.8	65–75	65–75
10	110	60	104.0	111.2	55–65	60–65
11	110	60	103.4	107.1	70–75	70–75
12	110	60	103.7	108.3	70–80	70–75
13	110	60	104.1	109.7	60–70	60–75

[a] Rabbits used in trials 8–13 were used in fertility tests.
[b] Motility figures after incubation are ranges for samples collected over a period of one month.

Results and Discussion of Preliminary Trials

Table 1 shows the semen quality and body temperature of rabbits before and after heating. It is noted that a temperature of 110° F. at a relative humidity of 30 to 40 percent for 1 hour did not affect the motility of spermatozoa in most cases, and also did not cause an observable change in sperm concentration (counts were not made). Exposure to a temperature higher than 110° F. for 30 minutes or more caused a marked decrease in motility of spermatozoa in the two animals that lived to be tested. Body temperature of the treated rabbits increased on the average 4.6° F. after incubation for 1 hour at 110° F. The range of the increase in body temperature was 2.8° to 7.2° F. No determina-

tion was made of the increase in testis temperature but such information would be desirable.

Material and Methods Used in Fertility Tests

Fertility tests were made in six different trials. Each trial included semen from one control rabbit and one treated rabbit, different males being used in each trial. Fertility tests were made at 7 days, 12 to 14 days, and 21 to 30 days after the incubation of the treated rabbit. The treated rabbits showed no decrease in percentage of spermatozoa showing forward movement after treatment. One to four female rabbits were inseminated with semen from each experimental and control male in

TABLE 2. FERTILITY COMPARISONS OF TREATED AND CONTROL RABBITS IN SIX DIFFERENT TRIALS

Male rabbits	Observations on female rabbits	Post treatment interval		
		7 days	12 to 16 days	21 to 30 days
Control	Number of females:			
	All eggs fertilized	8	9	15
	Part of eggs fertilized	3	3	3
	No eggs fertilized	0	0	0
	Total number of eggs	79	77	144
	% all eggs fertilized	96.2	92.2	97.2
Treated	Number of females:			
	All eggs fertilized	5	3	9
	Part of eggs fertilized	6	3	6
	No eggs fertilized	2	6	1
	Total number of eggs	83	81	111
	% all eggs fertilized	73.5	53.1	82.0

each trial at each of the three mentioned intervals. The female rabbits were injected intravenously with 50 I.U. of chorionic gonadotrophin to produce ovulation and were inseminated artificially with 0.5 cc. diluted semen (1 part semen to 9 parts Krebs solution). The females were killed 24 to 26 hours later and the eggs flushed from the oviducts with physiological saline and examined under the binocular microscope for evidence of fertilization (cleavage). The ratio of fertilized to unfertilized ova for each male rabbit was calculated.

Results and Discussion of Fertility Tests

Table 2 shows the fertility comparisons of treated and control rabbits. It is noted that while the percentage of fertilized ova for the control

rabbits in all six trials, 7 days after incubation, was 96.2, for the treated rabbits it was 73.5. At 12 to 16 days after incubation, the percentage for the controls was 92.2 and for the treated, 53.1. The percentage of fertilized ova at 21 to 30 days after incubation for the treated rabbits approached that for the controls.

The effect of heating on the ratio of fertilized to unfertilized eggs was significant ($P < .05$) as tested by analysis of Chi Square by the method of Rao (1952), a method of analysis which takes into consideration unequal subclass numbers. It seems that the effect of heat on fertility of spermatozoa was apparent by the 7th day after treatment. Young (1929) showed that the actively dividing primary and secondary spermatocytes and younger spermatids are the first elements to be affected by increased temperature. He concluded that older spermatids are affected next.

No significant interaction was found between treatment and interval-since-treatment on the fertility ratios for treated and controls at 7 days and at 12 to 16 days intervals after incubation. Thus, there was no evidence for a more intense effect of treatment at the latter stage than at the former. However, by comparing the difference in fertility of the control and treated rabbits, at 12 to 16 days with that at 21 to 30 days after incubation, a significant ($P < .05$) interaction was found. This interaction indicates that some recovery had occurred between these two stages.

Thus, it would appear that increased ambient temperature may affect male fertility without bringing about any apparent depression of sperm motility. It is not known at the present time whether the reduced fertility is due to the inability of spermatozoa to maintain their motility in the reproductive tract of the female till the eggs are shed (Asdell and Salisbury, 1941) or to other factors.

Summary

Exposing male rabbits to a temperature of 110° F. at a relative humidity of 30 to 40 percent for one hour did not affect the motility of spermatozoa in most cases. Fertility tests were made in six different trials, each including semen from one heat-treated rabbit and from one control. The treated rabbits exhibited no decrease in percentage of spermatozoa showing forward movement for one month after treatment. The effect of heating on the ratio of fertilized to unfertilized ova in test females was significant with some recovery by 21 to 30 days after treatment. It is concluded that increased ambient temperature may affect

male fertility without bringing about any apparent depression of sperm motility.

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MICROSTRUCTURE OF SPERMATOZOA AFTER DENUDATION AS REVEALED BY THE ELECTRON MICROSCOPE [1]

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BECAUSE of the close association between the structural and functional characteristics of the cell, the morphology of the spermatozoa has long been a subject of academic interest particularly since the introduction of artificial insemination as a tool in animal breeding.

The classical work of Retzius (1909) and that of many others have given a clear view of the fundamental pattern of the sperm architecture. Since the invention of the electron microscope the microstructure of the mammalian spermatozoa has been studied by several investigators (Bayle and Bessis, 1951; Baylor *et al.*, 1943; Bonadonna *et al.*, 1953; Bonadonna and Caretta, 1954; Bretschneider and van Iterson, 1947; Bretschneider, 1949; 1949b, 1950; Culp and Best, 1949; Hammen *et al.*, 1954; Hodge, 1949; Randall and Friedlaender, 1950; Reed and Reed, 1948; Seymour and Benmosche, 1941; Stockton and Gebhard, 1952; Wu and McKenzie, 1954). Yet the information accumulated to the present is still far from complete and the detailed organization within the sperm cell still remains a mystery in many respects. The present report is a study of denuding the spermatozoa with chemical reagents before electron microscopy so that the cellular components can be exposed for critical examination.

Experimental

The semen specimens from horses, cattle, sheep, swine and rabbits were collected by means of the artificial vagina using the methods essentially as those described by Lambert and McKenzie (1940). In the guinea pig the semen was obtained from the ductus deferens and in the human the spermatozoa were the contribution from healthy donors.

The fresh semen specimens were clarified by centrifuging 2 to 3 times with ethanol (25–33 percent) and distilled water and then filtered. The sperm left on the filter paper were then suspended either in dis-

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tilled water for NaOH treatment or in buffers for enzymatic digestion At the end of the treatment the reagents were removed by centrifugation and the spermatozoa were again suspended in distilled water. They were then mounted on the specimen screen by delivering a drop of the sperm suspension, which has a concentration of 1 to 2 million sperm per ml., on the collodion film in a wire grid. The supporting film in the grid was prepared according to the method described by Fischer (1950). The specimen on the collodion film was then dried and shadowed with chromium at an angle of 20 degrees to the horizontal and observed with an RCA Model EMU-2D electron microscope.

Results and Discussion

Spermatozoa are generally opaque to the electrons used for electron microscopy. Their cellular components, however, can be exposed and become clearly visible if they have been denuded by treatment with chemical reagents before observation with the electron microscope. Figure 1 shows a sperm head from a rabbit spermatozoon which has been treated with ether. Note that the anterior border of the posterior-nuclear cap is clearly visible. The density of the anterior portion of the sperm head appears to be greatly reduced and the head has become granular in appearance. Similar results have been observed when spermatozoa were treated with acetone. This diminution in opacity of the sperm head after treatment with fat solvents may indicate the presence of a lipoid membrane in some parts of the sperm head. This finding seems to confirm the observations in cytochemical studies of spermatozoa by other investigators. Thus, by using Sudan black staining technique it has been reported that lipids were present in the sheath surrounding the head of deer spermatozoa (Wislocki, 1949); in the equatorial zone of the human spermatozoa (Wislocki, 1950) and in the head of ram spermatozoa at the structure immediately below the head apex and in the area posterior to the anterior border of the posterior-nuclear cap (Friedlaender and Fraser, 1952).

Besides fat solvents we found that sperm heads show partial disintegration after pancreatic digestion. Figure 2 shows ram spermatozoa which have been incubated with pancreatin. One of the sperm heads has been partially digested with only its base left while the large part of the other head also shows disintegration with the appearance of granules and holes in most portions of the head except the head base. This may well illustrate the distribution of the chromatin material and the so-called head-plasm in the sperm head. It is interesting to compare this

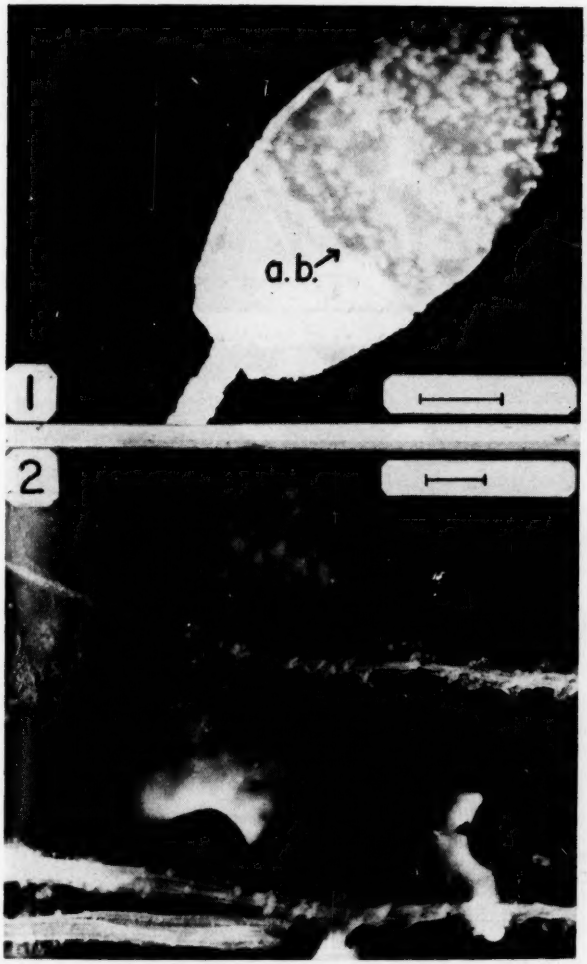

Figure 1. Head from rabbit spermatozoa treated with ether (1:1) at 37° C. for 16 hr. Note that the granular material becomes visible at the area in front of the anterior border (a.b.) of the posterior-nuclear cap × 15,000.

Figure 2. Head and middle-piece from a ram spermatozoon treated with pancreatin (0.25 percent in phosphate buffer) at 37° C. for 16 hr. Note that one of the heads has been almost completely digested with only the head base (h.b.) left. Large part of the other head also showing partial disintegration with the appearance of granules and holes in area besides the head base. × 10,900.

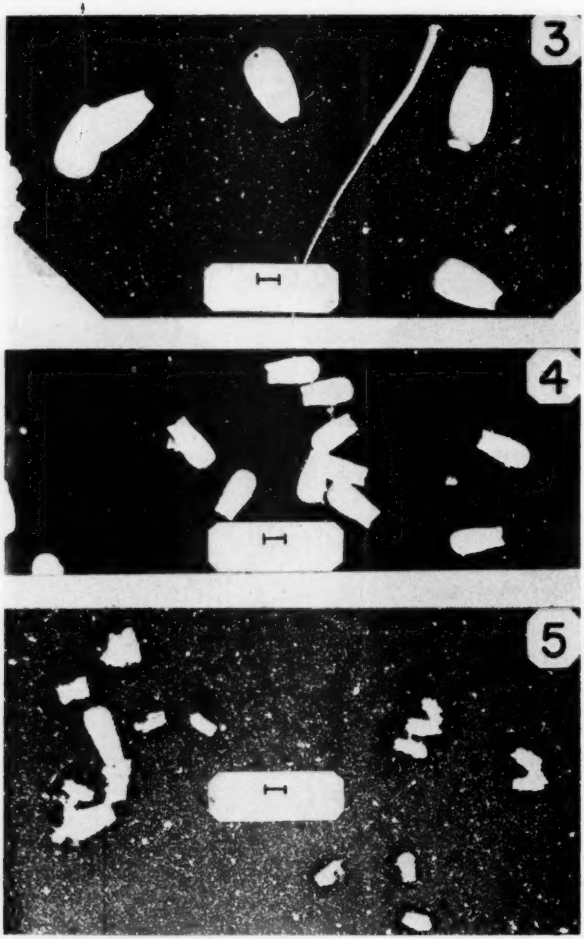

Figure 3. Head of bovine spermatozoa in distilled water at 5° C. for 21 days. Note the head size and the shape at the head base. Compare these with that seen in Figures 4 and 5. × 4,000.

Figure 4. Split sample from those showing in Figure 3 but treated with 0.2 N NaOH at 25° C. for 16 hr. Compare with those seen in Figure 3. Note the change in the shape of the head base and the reduction in head size after NaOH treatment. × 4,000.

Figure 5. Split sample from those shown in Figure 3 but treated with 0.4 N NaOH at 25° C. for 16 hr. Compare with those as seen in Figures 3 and 4. Note the further reduction in head size at higher concentration of NaOH. × 4,000.

with what has been found from cytochemical studies of ram spermatozoa by Friedlaender and Fraser (1952). These authors claimed that the desoxyribonucleic acid is highly concentrated in the sperm head in the area posterior to the anterior border of the posterior-nuclear cap whereas the area anterior to the equatorial zone contains mostly basic proteins.

The effect of NaOH on the sperm head appears to be different from those of pancreatin and fat solvents. Figures 3, 4 and 5 show the head of bovine spermatozoa from the same ejaculate of bovine semen but subjected to different treatments. The sperm heads showing in figure 3 were from spermatozoa which have not been treated with NaOH, those in figure 4 were from spermatozoa treated with 0.2 N NaOH, and in figure 5 were from sperm treated with 0.4 N NaOH. Note that the head size diminishes from the edge toward the center of the head, and that this diminishing in head size after NaOH treatment parallels the increase in NaOH concentration. It is highly probable that this is due to the presence of more than one layer of structural units in the sperm head.

After treating the spermatozoa with NaOH or pancreatin many of their internal structures become clearly visible. The micrographs suggest that the acrosome appears to compose a tubular sheath containing a fibrillar central core (figure 7). It attaches along the anterior border of the sperm head and is invested in the galea capitis. Based on our micrographs we agree with the general belief that acrosome and galea capitis are two different structures of the sperm cell. This conclusion differs from that of Hancock (1952) who concluded, in his studies of bovine spermatozoa, that the terms acrosome and galea capitis have been used to describe the same structure.

The middle-piece of the sperm cell has long been considered as the locomotion center, yet, many points in its structure are still not known with certainty. By subjecting spermatozoa to pancreatin digestion we have been able to reveal the finer structure of the broad helix. Figure 18 shows the middle-piece of a ram spermatozoon which has been treated with pancreatin. The membranes covering the middle-piece (figure 16) have been removed. The broad helix (figure 17) and the mitochondrial sheath surrounding the axial filament have also been slightly disintegrated. This partial disintegration of the middle-piece makes it possible to demonstrate very clearly the inner organization of the broad helix. The micrographs show that the broad helix is composed of numerous granules lying closely together within the mitochondrial sheath which

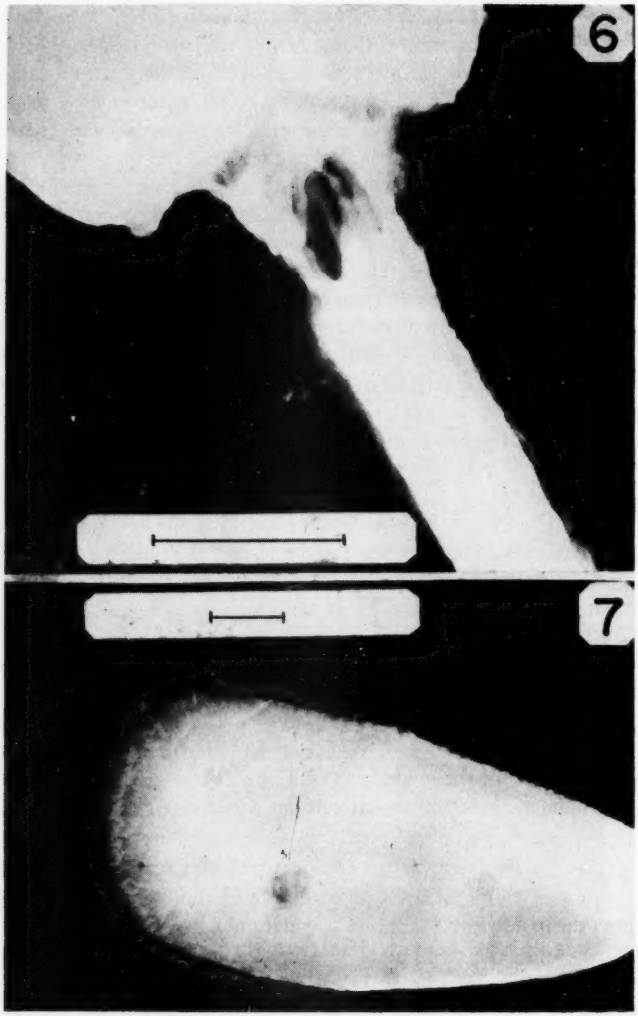

Figure 6. Head-neck junction of the ram spermatozoon, showing the fibrillar strands in the neck region and their junction with the inner shell of the head. × 31,300.

Figure 7. Head of ram spermatozoon. Note the fibrillar structure closely attached along the anterior border of the sperm head. × 12,000.

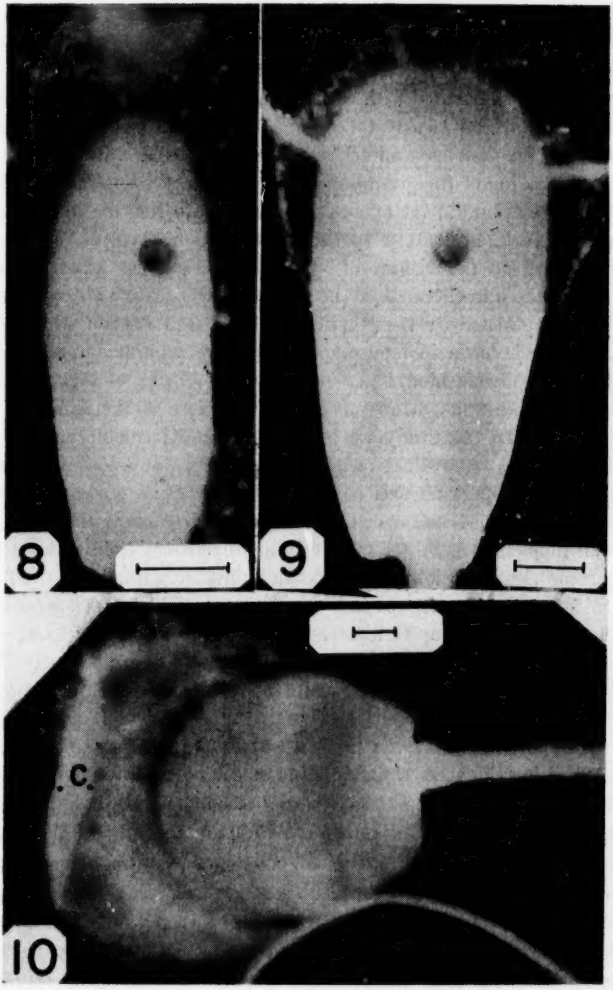

Figure 8. Head of stallion spermatozoon fixed in 1 percent formaldehyde at 37° C. for 10 hr. showing the galea capitis (g.c.). × 16,000.

Figure 9. Head of bovine spermatozoon fixed in 1 percent osmium tetraoxide at 5° C. for 7 days showing the galea capitis. × 12,000.

Figure 10. Head of guinea pig spermatozoon fixed with 1 percent osmium tetraoxide at 37° C. for 16 hr. showing the galea capitis. × 7,500.

wind around the axial filament in a spiral fashion (figure 18). Figure 21 shows a ram spermatozoon treated with papain. Note the continuation of the helical structure up to the tip of the tail end. Figure 22 shows a boar spermatozoon treated with pancreatin. The head was detached. The remaining parts show clearly the cytoplasmic sheath covering the axial filament and the dislodged mitochondrial sheath with its granular inclusions. This finding of the granules inside of the mitochrondrial sheath is worthy of attention. So far as we know at the present, the locations of the mitochondria in mature spermatozoa have not yet been demonstrated. Based on the history of spermatogenesis these granules seem to represent the mitochondria of the mature sperm cells. This contention may be strengthened by the recent finding of Bell (1953) who shows that the mitochondria in mouse spermatids are separate granules and arranged in a spiral fashion.

Another interesting feature of the middle-piece is the fibril of the axial filament. In this study we found that NaOH can be used as an effective agent to remove the membranes covering the middle-piece and those of the tail part as well as the helical structure surrounding the axial filament of the sperm cell. Through this treatment the fibrils of the axial filament can be set free from all their surrounding structures and become clearly visible as well defined units. Figures 11, 12, 13, 14 and 15 show the fraying of the fibrils in spermatozoa treated with NaOH. These micrographs illustrate very clearly that the axial filament of spermatozoa from human, bull, ram, rabbit, and boar each consists of 9 fibrils. Three or four of these 9 fibrils have greater diameter than the remainder. The individual fibril appears as thin ribbon and each seems to consist of even finer sub-units. The flatness of the individual fibril is evidenced by its twisting as seen in the micrographs. By critical examination the presence of periodical transverse banding on the individual fibril can also be observed, and the continuation of these fibrils up to the tail end is shown in Figure 20 where a ram spermatozoon has been treated with pancreatin. It is a general belief that the axial filament originates from the mitochondria, but there is conflict of opinion regarding the number of fibrils in the axial filament. Thus, the number of the fibrils in the axial filament has been claimed to be 12 (Randall and Friedlaender, 1950) or 9 (Bonadonna, 1954) in ram spermatozoa; 9 in bovine, stallion, and dog spermatozoa (Bretschneider, 1949, 1949a), or 11 to 20 (Bonadonna, 1954) in stallion spermatozoa; and 9 or 11 in human spermatozoa (Hodge, 1949). It is probable that the variations in observed fibril number were due to the diversity of techniques

used by the various investigators. It is interesting to compare our consistent observation of 9 fibrils in the axial filament of spermatozoa from human, bull, ram, rabbit and boar with the number of fibrils reported in the flagellum. Kraneveld *et al.* (1951) found that in *Trypanosoma evansi* the flagellum consists of parallel isodiametric fibrils, and the number of fibrils in the flagellum is also found to be 9 as we found in the axial filament of the sperm cell. This constitutional similarity between the flagellum of trypanosomes and the axial filament of spermatozoa may reflect their functional analogy, and our finding may well support the view of Grigg and Hodge (1949) in that the fibrils in the sperm cell may be construed as contractile elements analogous to those described in striated muscle by Hall *et al.* (1946) and Draper and Hodge (1949).

The action of the different reagents varies considerably in different parts of the spermatozoa. This may indicate the constitutional characteristics of the different loci of the sperm cell. The galea capitis (figures 8, 9 and 10) appears to be the most fragile structure of the spermatozoa. It is seldom to be observed under the electron microscope unless fixation has been employed. This is probably due to the high water content of this structure (Bretschneider, 1949) and the force of surface tension exerted on this area during the drying process in the preparing of the specimen. Incomplete fixation or mechanical agitation may suffice to cause its disappearance.

The head-neck junction is another weak point in the sperm cell. The head usually becomes detached from the other part of spermatozoon after treating the sperm with NaOH or pancreatin. In many cases we found that the head base of an untreated sperm differs from that of the head detached from the spermatozoa after NaOH treatment (figures 3 and 4). This difference may indicate the presence of a membrane near the head-neck junction in the intact spermatozoa. And it seems also that the disintegration of this membrane alone will not always cause the separation of the sperm head from the rest of the cell (figures 12 and 13). The question of what substance cements the head and neck together is still obscure. Our micrographs show, however, that the fibrils of the middle-piece form 3 or 4 strands or articulations at the neck region and these strands project through the head base into the inner structure of the sperm head (figure 6).

The membranes covering the middle piece and those of the tail part react differently toward enzymatic digestion. Figure 20 shows the transition of the middle-piece and the tail region of bovine spermatozoa

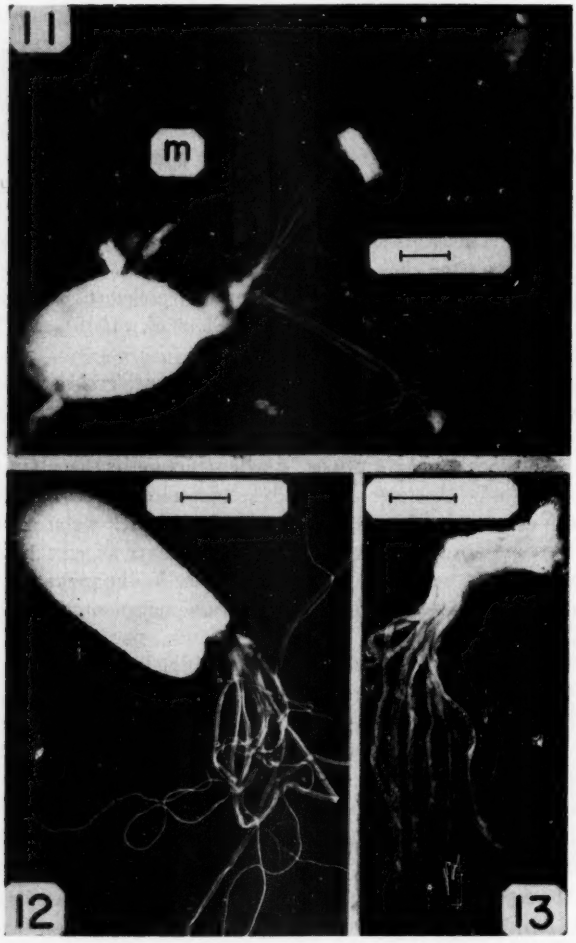

Figure 11. Human spermatozoon treated with 0.15 N NaOH at 25° C. for 68 hr. Showing the fraying of 9 fibrils. Note also the partially disintegrated membrane (m) beside the sperm cell. × 9,000.

Figure 12. Boar spermatozoon treated with 0.1 N NaOH at 37° C. for 12 hr. showing fraying of the 9 fibrils. Note that the fibrils appear as thin ribbons. × 9,000.

Figure 13. Middle-piece from rabbit spermatozoon treated with 0.05 N NaOH at 25° C. for 12 hr. showing the fraying of the fibrils in the axial filaments. Note that there are 9 fibrils in the axial filament and each appears to contain finer sub-units. × 12,000.

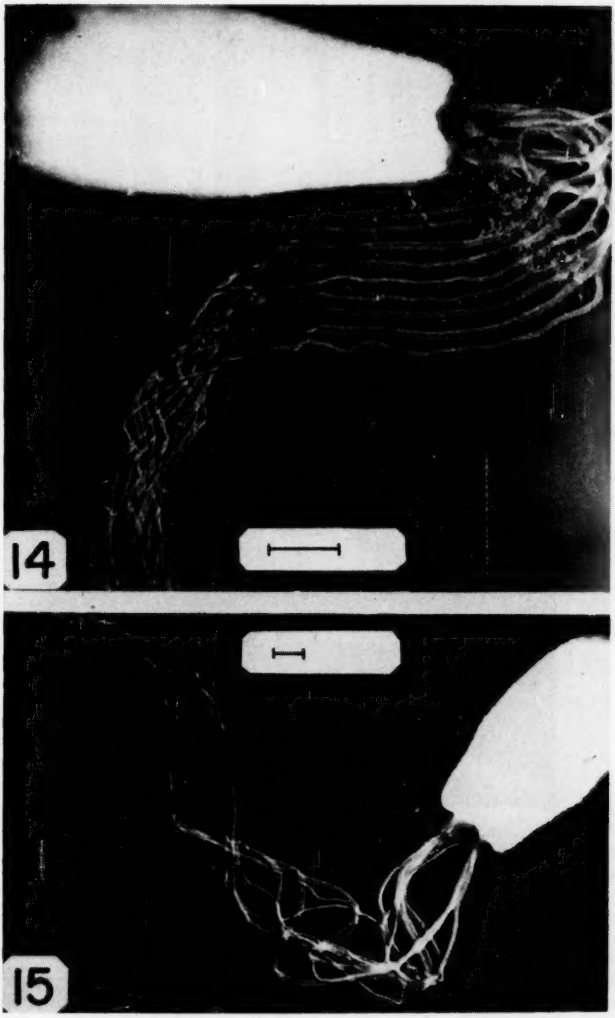

Figure 14. Bovine spermatozoon treated with 0.15 N NaOH at 25° C. for 16 hr. showing the fraying of the 9 fibrils and 3 or 4 of the fibrils have greater diameter than the remainder. Note also the fibrils appear as thin ribbons. × 12,000.

Figure 15. Ram spermatozoon treated with 0.15 N NaOH at 25° C. for 68 hr. showing the fraying of the 9 fibrils. × 5,000.

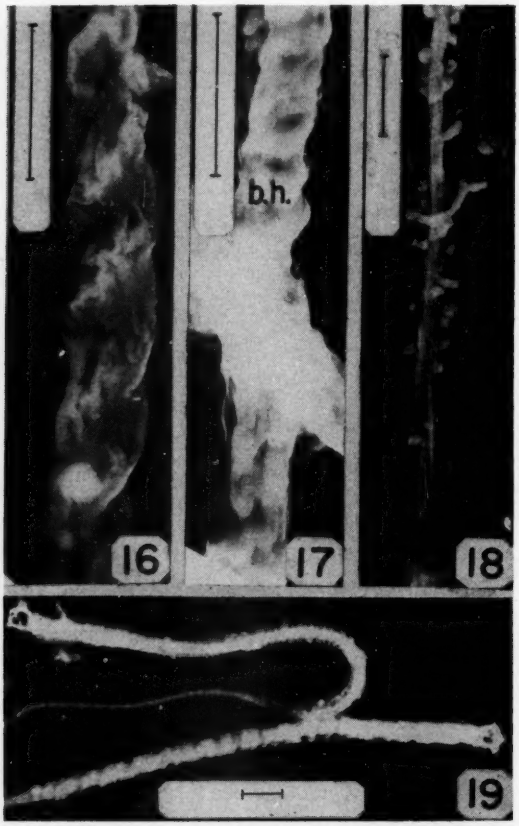

Figure 16. Structure from middle-piece of ram spermatozoon treated with 0.025 percent papain in phosphate buffer at 25° C. for 16 hr. The structure appears to be the membrane surrounding the middle-piece; note its spiral appearance. × 31,300.

Figure 17. Structure from the middle-piece of boar spermatozoon treated with 1 percent pancreatin at 37° C. for 15 min. showing the thin membrane covering the broad helix (b.h.). × 32,900.

Figure 18. Structure from the middle-piece of ram spermatozoon treated with 0.375 percent pancreatin at 37° C. for 16 hr. showing further disintegration of the middle-piece; the broad helix is dislodged and the granular inclusions within the mitochondrial sheath (m.s.) become clearly visible. × 16,500.

Figure 19. Transition between the middle-piece and tail region of bovine spermatozoon treated with 0.2 percent pancreatin at 37° C. for 12 hr. The membranes covering the tail region have been removed and the fibrils of the axial filament have become clearly visible. The membranes covering the middle-piece have not been much affected. × 8,200.

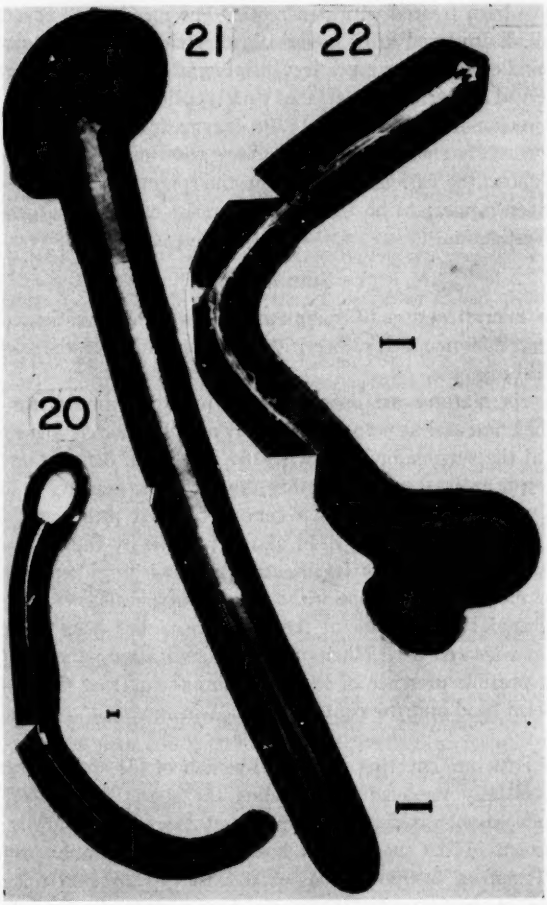

Figure 20. Ram spermatozoon treated with 0.2 percent pancreatin at 25° C. for 16 hr. showing the continuation of the axial filament to the end of the tail. Note also the partially disintegrated membrane. × 1,980.

Figure 21. Ram spermatozoon (head detached) treated with 0.025 percent papain at 25° C. for 16 hr. showing the continuation of the cortical structures from the neck base to the tip of the tail end. × 6,600.

Figure 22. Boar spermatozoon (head detached) treated with 0.15 percent pancreatin at 37° C. for 10 hr. showing the granular inclusions within the dislodged mitochondrial sheath. × 6,400.

which have been treated with pancreatin. The membranes covering the sperm tail disappeared after pancreatic digestion whereas those covering the middle-piece show much less disintegration. Similar changes have been observed in spermatozoa treated with trypsin.

The mitochondrial sheath resists the enzymatic digestion used in this study but usually shows complete disintegration under the influence of NaOH. Among the various structures in the sperm cell the fibrils of the axial filament appear to be the ones that resist most the reagents used in this investigation.

Summary

1. The microstructure of spermatozoa has been investigated using the electron microscope together with the denudation of the sperm cell by chemical reagents.

2. The spermatozoa are opaque to electrons used in electron microscope. Their internal structures, however, may become visible after the removal of the surrounding structures by "chemical denudation."

3. Electron micrographs show that the acrosome appears to be composed of a tubular sheath and a central core; it attaches along the anterior border of the sperm head and is covered by the galea capitis. The galea capitis is a very fragile structure and is seldom to be seen under the electron microscope without previous fixation.

4. A granular appearance of the sperm head has been observed in spermatozoa treated with ether or acetone and after pancreatic digestion. The possible presence of lipoid membrane covering the front part of the sperm head and the content of DNA in the head area have been discussed.

5. The structure covering the axial filament of the spermatozoon has been successfully removed by denuding the sperm with NaOH. The micrographs so obtained demonstrate that there are 9 fibrils in the axial filament of the sperm from human, bull, ram, rabbit and boar. The fibrils appear as thin ribbons of at least two different thicknesses. Periodicity of the individual fibrils has been observed and each of the 9 fibrils appears to consist of even finer sub-units.

6. The microstructures of the broad helix have been revealed by the removal of its surrounding structures through pancreatic digestion. Micrographs show that the broad helix is composed of numerous granules lying together within the clearly visible tubular mitochondrial sheath.

7. The micrographs also show the continuation of the fibrils of the axial filament and the helical structure from the neck up to the tail end of the sperm cell.

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FEEDING VALUE OF STORED CORN

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ALTHOUGH there has been an increase in the amount of stored corn during recent years, the total amount of surplus in the United States has never exceeded a year's supply. However, some grain in government and other storage attains an age of several years before it is used.

It is well recognized that normal metabolism of grain tissues, decomposition caused by microorganisms, infestations of insects and mites as well as attacks by rodents and birds cause considerable losses in stored grains. Some experimental work to determine the exact nature of such losses and methods for prevention has been reported. Experiments at the University of Illinois by Fairbanks *et al.* (1940), showed that swine fed sound corn gained at a faster rate on less food per day than similar animals fed moldy corn. Jones *et al.* (1942), using small samples kept in laboratory containers, found that protein values of freshly harvested ripe corn decreased during the first few weeks of storage but no deterioration occurred during the second year.

As better methods of grain preservation have been developed, little has been done to assess the feeding value of corn that has been stored in bulk quantities under relatively good practical conditions.

The purpose of this work was to determine the extent of deterioration, if any, of the feeding value of corn stored with proper moisture content and kept in volume under relatively good conditions. Results of rat growth, and protein and feed efficiencies are reported on two different types of feeding experiments. These tests were designed to estimate possible deterioration in protein nutritive value and the value of corn as a source of energy in animal diets.

Experimental

Corn Samples

Nine samples of stored shelled corn were obtained from government surplus stocks. Five were from Story County, Iowa, representing harvests of five years from 1948 to 1952, inclusive. Three were from

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Woodbury County, Iowa, including harvests of 1948, 1949, and 1952. One sample from the latest crop available, harvested in 1953 at the Experimental Station at Beltsville, was used as a control. It was approximately one year of age at the time the experiments were made. All of the samples were taken from round, 3250 bu., steel bins and flat type quonset structures having capacities of 35,000 to 40,000 bushels. Since these were all filled to about capacity, the quantities just named represent the bulk sampled. All were field dried, yellow corn, though no information was available on the varieties represented. The samples were classified as to approximate commercial grade according to official grain standards.

Diets

Two separate rat feeding experiments were conducted on the corn samples. In both experiments, 9 diets were prepared. The first experiment was designed especially to compare the nutritive value of the protein in the corn samples at a restricted level of 8 percent protein in the diet. One of the corn samples, finely ground, was included in each diet as the only variable. Since the corn was the only source of protein, the 8 percent level was obtained by varying the amount of corn in relation to its protein content.

In the second experiment, some protein in the diets was furnished by alfalfa and soybean oil meals to bring the total protein to approximately 15 percent. As all the diet ingredients including corn meal were kept constant, a small variation in protein level necessarily resulted in these diets. Composition of the diets used in both experiments are given in table 1.

Weanling rats were used as test animals. Usually 3 to 4 animals of the same sex were available from the same litter. An incomplete block design was employed in the arrangement of the litters of rats on the 9 diets. A 3 $\times$ 3 balanced lattice was adopted similar to the plan used in a feeding trial with swine by Comstock *et al.* (1948). According to that plan the rats were divided into sets of 3 litter mates. Two sets, 3 males and 3 females, were assigned to each block. This gave an experimental unit of 1 male and 1 female rat, thus 4 rats of each sex provided 4 replications of the unit. Animals were fed the diets ad libitum in individual cages for a period of 4 weeks. Weekly weight and food consumption records were obtained.

In the second experiment the rats obtained from the same colony a few days later, were of the same age and otherwise similar to those

used in the first experiment. These were divided into 8 groups of 9 each, according to sex and body weight. They were then randomly assigned to the 9 corn mixed-protein diets. Thus, this experiment was a randomized complete block design with 8 replications. These animals were also given the diets ad libitum in individual cages. Records of weight and food consumption were obtained weekly.

TABLE 1. DIETS USED IN TESTING NUTRITIVE VALUE OF STORED CORN

	Corn protein diet	Mixed protein diet
	parts/100 gm.	parts/100 gm.
Corn	[a]	80.0
Dextrinized starch	[a]	...
Soybean meal	...	17.0
Alfalfa meal	...	2.0
Lysine	0.45	...
Tryptophane	0.10	...
Mineral mix [c] #12	2.5	1.0
Calcium carbonate	0.7	...
Aureomycin	...	.8 mg.
Riboflavin	0.7 mg.	.8 mg.
Calcium pantothenate	4.5 mg.	4.7 mg.
Niacin	...	2.75 mg.
Thiamin	0.4 mg.	...
Pyridoxine	0.7 mg.	...
Choline	100.0 mg.	...
Vitamin B_{12}	3.0 mcg.	3.0 mcg.
Cod liver oil	[b]	...

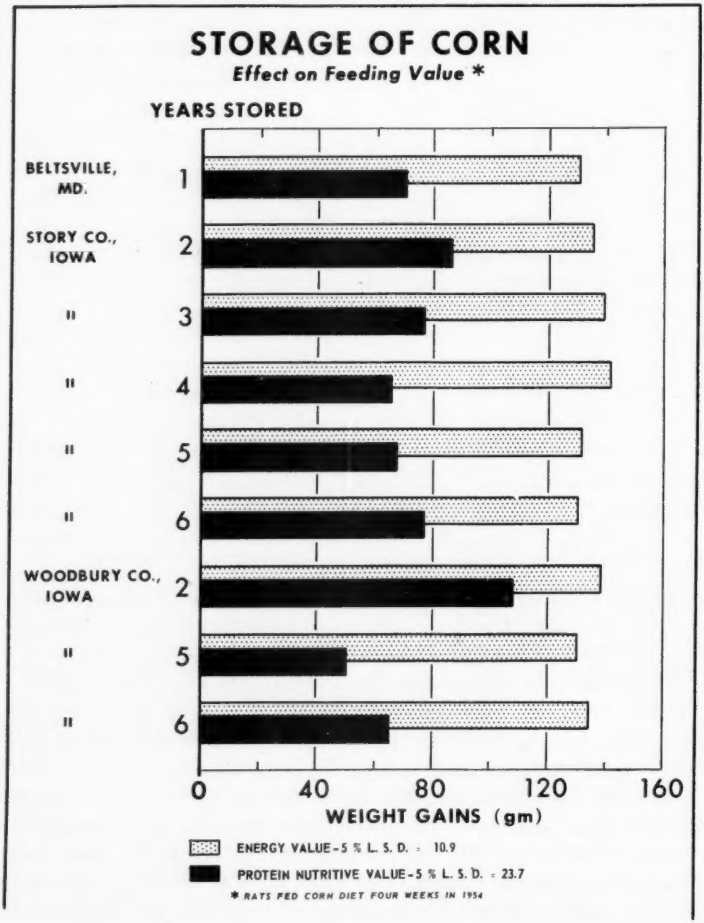
[a] Starch and corn varied so as to provide a level of 8 percent protein in diet.
[b] Fifteen drops of fortified cod liver oil per rat twice each week.
[c] Salt mix No. 12 of Jones and Foster (1942).

Results

Figure 1 summarizes growth of all the animals in both experiments. In the bar chart, the dark bars show variation in protein nutritive value in the corn samples as measured by the adjusted mean gains on the 8 percent protein level diets. Some deterioration in protein nutritive value is indicated by the older corn samples from both locations. When comparison is made between samples from the same location, significance at $p = .05$ is shown only in the corn from Woodbury County. The dotted bars show mean weight gains of the rats fed corn in the mixed protein diets. The small differences shown by these growth measurements are not statistically significant at the .05 probability level. Rats from all these groups averaged almost 5 gm. body weight gain per day. This is equal to growth for this strain of rats when fed No. 1 stock

diet as used in this laboratory for breeding animals and described by Eaton and Cabell (1949).

From food consumption and weight gains, protein and feed efficiency values were calculated. Only the protein efficiency calculated from the protein nutritive experiment and feed efficiency values from the energy value experiment are given in table 2 since they are sufficient to illustrate the effects obtained.



The indication is that the older corn samples have deteriorated some in protein value, though differences statistically significant at the $p = .05$ level for within area comparisons are shown only in the Woodbury County samples. Furthermore, even if some protein deterioration did occur in the older samples of corn, the supplementary protein value was not impaired in the particular diets used in the growth tests of Experiment 2. The insignificant differences in the feed efficiency values show that no measurable loss occurred in the corn samples when used as a source of energy in these diets.

TABLE 2. NUTRITIVE VALUE OF STORED CORN
(Expressed as Protein and Feed Efficiency Compared with Other Determined Values)

Location	Age	Commercial grade	Crude protein N X 6.25	Free fat acidity	Protein [a] efficiency gain/gm./ protein	Feed [b] efficiency feed/gm./ gain
	years		%		gm.	gm.
Beltsville, Md.	1	3	9.05	30.3	2.24	2.72
Story Co., Iowa	2	3	8.80	...	2.43	2.86
"	3	4	8.52	47.2	2.31	2.80
"	4	3	8.26	45.4	2.04	2.72
"	5	5	8.72	35.0	2.19	2.84
"	6	4	8.38	44.3	2.31	2.86
Woodbury Co., Iowa	2	1	8.04	...	2.74	2.79
"	5	3	9.08	45.1	1.81	2.88
"	6	sample	9.46	56.3	2.08	2.86
F ratio	..	..	...	...	3.60*	1.52
L.S.D.[c] P = .05	..	..	...	...	0.41	0.15
P = .01	..	..	...	...	0.57	0.20

[a] Calculated from data obtained in experiment to determine protein nutritive value.
[b] Calculated from data from energy value experiment.
[c] Least significant mean difference.
* Significant at .05 probability level.

Examination of the data in table 2 shows considerable range in commercial grade of the corn samples. Just how this affected rat growth is not known, but some correlation with protein nutritive value is indicated by the No. 1 commercial grade corn having the highest protein efficiency value (2.74) and the sample grade corn a low protein efficiency of 2.08. Free fat acidity, suggested by Zeleny and Coleman (1939) as a measure of the soundness of corn, was determined on some of the samples. These values are included in table 2. Some correlation with age of the corn samples is indicated.

It is of interest to observe the relative efficiencies of the experimental designs employed in these tests. One instance of the use of balanced lattice design to rat feeding experiments is described by Sherwood *et al.* (1954). Efficiency was increased over randomized block design by about

7 percent. In the balanced lattice used in testing this corn, increased efficiency obtained was 16 percent. This is still less than the gain in precision of 25 percent suggested as average for agronomic experiments with this design by Cochran and Cox (1950). However, 16 percent gain would seem to be worth the necessary increased calculations involved. Apparently grouping according to litter and body weight was of some value. It may be that within-litter variation is of importance in measuring differences at restricted protein levels as it has been shown to be in vitamin D assays by Bliss (1954). Opposed to this view, Harte *et al.* (1947) have shown data to indicate no advantage in using litter mates as compared to randomly chosen males in protein assays by rat growth. However, their experiments were with casein, a more adequate protein, and at a higher level of protein (10 percent) in the diet.

In the second corn experiment in which protein levels were approximately 15 percent, the calculated least significant mean differences are much smaller than in the balanced lattice. This smaller variation in individual animals would be expected at the adequate protein level of these diets. The coefficient of variation, Snedecor (1946), calculated from the error variance of the 15 percent protein diets was 7.5 percent as compared to that calculated from the effective error variance of the balanced lattice of 22 percent.

Summary and Conclusions

Nine samples of stored surplus corn ranging from one to six years of age were tested by rat feeding experiments to estimate possible deterioration of nutritive value.

The samples were obtained from government surplus storage held in 3250 bushel steel bins and 35,000 to 40,000 bushel quonset structures.

Data from two experiments are reported. A 3×3 balanced lattice design to compare protein nutritive value of the samples indicated a decrease in protein efficiency from 2.72 to 1.81 gm. in corn from one location after five years storage. Other samples obtained from a different location indicated no loss statistically significant at $P = .05$ after six years storage. When corn was fed as a source of energy in mixed diets, no loss in feeding value was found in samples stored for as much as six years.

An increased efficiency of 16 percent was obtained by use of a balanced lattice design in one of the rat feeding experiments.

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE FORTY-SEVENTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meetings are scheduled to be held at the Hotel Sherman in Chicago, Illinois, on November 25 and 26, 1955. Abstracts have been submitted for the following papers.

Breeding and Genetics Section

H. H. Stonaker, *Chairman*

MILK PRODUCTION OF SOWS AS CORRELATED WITH THE PERFORMANCE OF PIGS. Arthur D. Allen, Roy O. Baker and John F. Lasley, *University of Missouri.*

The milk production of 12 Duroc, 3 Poland, 7 Landrace and 4 crossbred Landrace × Poland sows was determined once each week for 6 weeks by weighing the pigs before and after nursing. Average milk production for the 6-week lactation period was 225 lb. for the Durocs, 271 lb. for the Polands, 277 lb. for the Landrace × Polands and 305 lb. for the Landrace sows. The peak in milk production was reached during the fourth week by the Poland sows, during the fifth week by the Landrace and during the third week by the Duroc and Landrace × Poland sows. Creep feed consumption by the pigs was positively correlated with milk production by the sows in all breeds but this correlation was not significant on a within breed basis. Sows from the different breeding groups varied considerably in weight gains and losses during lactation. The Duroc sows gained an average of 7 lb. whereas the Poland, Landrace × Poland and Landrace sows lost 15, 44 and 22 lb. respectively. On a within breed basis, a highly significant correlation was found between milk production and weight losses in sows ($P < .01$). For each additional pound of milk produced, the sows lost 0.35 lb. in body weight. A larger litter weight at weaning was correlated with a greater loss in body weight during lactation on a within breed basis ($P < .05$).

CONTROL OF THE ERROR VARIANCE IN SWINE FEEDING TRIALS. I. BY COVARIANCE ADJUSTMENT FOR PRE-EXPERIMENTAL MEASURES. G. C. Ashton, H. L. Lucas, Jr. and F. W. Sherwood, *Iowa and North Carolina Agricultural Experiment Stations.*

Data from some 2500 pigs were used to study the variation in rate of gain and to evaluate the magnitude of reduction that can be obtained in this variation by making allowance through computational methods (covariance analysis) for the effects of covariables measured pre-experimentally. The covariables considered were weight, age, pre-experimental gain, body length, heart girth, serum protein-bound iodine and phosphatase activity, and nitrogen balance, all determined at or near the start of the feeding period. On the average, covariance adjustment for variation in initial weight reduced the coefficients of variation for rate of gain to 90 percent of the unadjusted values. Many adjusted coefficents remained above 10

percent, however. This adjustment is equivalent to a reduction of approximately 20 percent in the error variance and in the number of animals required to attain a given experimental sensitivity. Initial age, pre-experimental gain, body length and heart girth, singly and in combination, were of low utility for reducing the variation in rate of gain. Covariance adjustment for nitrogen balance and, in one study, for serum phosphatase activity reduced error variances by about 20 and 15 percent respectively, but, in two studies, adjustment for the level of serum protein-bound iodine yielded a reduction of almost zero.

CONTROL OF THE ERROR VARIANCE IN SWINE FEEDING TRIALS. II. BY BLOCKING AND SELECTION WITH RESPECT TO LITTER, SEX AND BREEDING. G. C. Ashton, H. L. Lucas, Jr. and F. W. Sherwood, *Iowa and North Carolina Agricultural Experiment Stations.*

Data from some 2000 pigs, fed for approximately 112 days, were studied to ascertain the variation in rate of gain and to evaluate the magnitude of the reduction that can be obtained in this variation by consideration of factors such as litter, sex and breeding prior to the initiation of a swine feeding trial. Blocking on litter reduced the average coefficient of variation for rate of gain to about 75 percent, and covariance adjustment for variability in intial weight in addition to blocking on litter lowered it to about 70 percent of the value obtained with neither blocking nor covariance. These reductions represent savings of about 45 and 50 percent in the number of pigs required to attain a given precision. Coefficients of variation in some breeds and crosses were nearly double those for pigs of other genetic constitutions. Average coefficients of variation of 10 percent for barrows were 85 percent as large as those for gilt pigs.

CONTROL OF THE ERROR VARIANCE IN SWINE FEEDING TRIALS. III. BY CONTROL OF EXPERIMENTAL CONDITIONS. G. C. Ashton, H. L. Lucas, Jr. and F. W. Sherwood, *Iowa and North Carolina Agricultural Experiment Stations.*

Data from some 1200 pigs were used to study the variation in the rate of gain and to evaluate the magnitude of the reduction that can be obtained in this variation by controlling managerial procedures. The managerial procedures considered included the length of the feeding period, unspecified factors reflected in the average rate of gain maintained, and the adequacy of the ration fed. Feeding periods of 28, 42, 84, and 112 days for growing-finishing pigs yielded average coefficients of variation for rate of gain of approximately 18, 15, 13, and 10 percent, respectively. For pigs at the same live weights the magnitude of the coefficient of variation in rate of gain was negatively associated with rate of gain, decreasing 1 to 2 units percent for each one-tenth pound increase in the rate of gain. Data from pigs fed approximately 112 days on rations that were nutritionally adequate yielded coefficients of variation for rate of gain that were only 50 percent as large as those for data from pigs fed rations that were nutritionally incomplete. Under conditions of inadequate nutrition the average coefficients of variation increased in magnitude whereas under more optimal conditions they decreased as the period of feeding was lengthened.

BODY MEASUREMENTS, SCORES, GAINS, AND FEED EFFICIENCY OF GROWING BEEF CATTLE. Ralph Bogart, G. E. Nelms, R. W. Mason, D. A. Price, C. E. Shelby and R. T. Clark, *Oregon State College & Agric. Research Serv., U.S.D.A.*

A study was made in which 27 Angus heifer, 27 Angus bull, 49 Hereford heifer, and 42 Hereford bull calves were measured and scored at 500 and 800 lb. body

weight. Birth date, birth weight, suckling gain, age at 500 lb., age at 800 lb., average daily gain from 500 to 800 lb., and feed per unit of gain from 500 to 800 lb. body weight were obtained for each calf included in the study. Body measurements at both weights included body length, chest width, chest depth, wither height, heart girth, paunch circumference, and rump and round measurements. Analysis of variance was determined for each of the 25 observations using the nested classification in which variance due to years, lines within years, and sires within lines within years was tested for signficance. Hefer records were adjusted to a male basis. There was a significant effect of year on birth date, age at 800 lb., rate of gain, length of body, and depth of chest at 500 and 800 lb. body weight; heart girth, chest width, paunch circumference, and rump measurements at 500 lb.; wither height and round measurements at 800 lb. There was a significant effect of lines within years for suckling gains, gains from 500 to 800 lb., body length, chest width, heart girth, and rump measurements at 800 lb., wither height and heart girth at 500 lb., score at 800 lb., feed per unit of gain, and birth weights. Sires within lines within years had a significant effect upon score at 500 lb., and age at 800 lb.

SELECTION FOR EFFICIENCY OF GAIN IN LAMBS. M. P. Botkin, *University of Wyoming*.

Ninety-five lambs were fed individually during the winter of 1953–54 and 89 during 1954–55 to obtain information as to the correlation between rate and efficiency of gain and as to heritability of these traits. Each group was handled differently, and a separate analysis was made for each. Gross correlation between gain and feed per lb. gain was —.72 for each group. Partial correlations, with initial weight held constant were —.80 and —.78 for the two groups. These correlations are high enough that feed efficiency can be estimated fairly accurately when initial weight and gain are known. Correlations were .80 and .87 between actual and estimated efficiency. Correlations between initial weight and rate of gain were .09 and —.08, while correlations between initial weight and feed per lb. gain were .33 and .47. There seems to be little relationship between initial weight and gain, but the larger lambs were less efficient. Heritability estimates were determined by half-sib correlations for the 89 lambs fed in 1954–55, which were from 13 sires. Heritability for rate of gain was .84 and for feed per lb. gain was .15. While these data give an indication, greater numbers of sire groups would increase the reliability. Ram lambs gained faster and were more efficient than ewe lambs. From the data presented, it appears that efficiency can be improved essentially as much by selection for rate of gain as by selection for efficiency.

RELATION OF SALE PRICE TO CERTAIN MEASURES OF MERIT IN PERFORMANCE TESTED BULLS SOLD AT AUCTION. C. J. Brown, Maurice L. Ray and Warren Gifford, *University of Arkansas*.

From 1952 through 1955, 27 Hereford and 40 Aberdeen Angus purebred bulls have been sold to the highest bidder at a public auction conducted as a part of an annual study day on beef cattle breeding and performance at the Arkansas Experiment Station. Each of the bulls was raised by the station and had previously been individually fed on a gain evaluation test for 154 days in dry lot. Available performance data on each of the bulls and his near relatives were made available and discussed with the buyers. Within breed and year, feed lot gain (.41), feed consumption (.30), conformation score (.64), and sale weight (.46) were significantly correlated with sale price. Correlations between sale price and 120-day weight, initial test weight, feed per pound of gain on test, initial test age, and sale age were positive but not significant. A multiple regression analysis yielded standard

partial regression coefficients of —.07 for 120-day weight, .10 for feed lot gain, .13 for feed consumption, .56 for conformation score, and .20 for sale weight when these measures of merit were used as independent variables to estimate sale price. These five items accounted for only 51% of the variation in sale price.

BULL AND LINE DIFFERENCES IN THE SURVIVAL OF SPERM AFTER FREEZING AND THAWING. N. C. Buch, Vearl R. Smith and W. J. Tyler, *University of Wisconsin.*

Differences in the percentage survival of sperm after freezing and thawing were studied for 12 Holstein-Friesian bulls representing six inbred lines. Regular collections were made every week for six weeks and motility comparisons made between diluted and glycerolated semen before freezing. After freezing, comparisons were made of the percentage of motile sperm at periods of 0, 1, 3, 7, 14, 28, 56 and 84 days. The percent of live cells was determined by visual estimation, the correlation between the visual estimation and the eosin-nigrosin stain technique being .66. No line nor bull differences existed at the two pre-freezing periods. However, there was a highly significant decline in the percentage of motile cells between the diluted and after equilibration with glycerol for all bulls. At various periods post-freezing, the analysis of variance indicated a highly significant difference between the periods. The drop in percentage of motile cells after freezing was at the rate of 2 percent per week for the 1st and 2nd weeks, 1 percent for the 3rd and 4th weeks together, and 1 percent additional drop during the 5th to 8th and also 9th to 12th week. The variation between bulls of the same line was not uniform; however, the difference between the bulls within lines was highly significant. No line differences were observed in the survivability of sperm after feezing. Bulls within lines responded differently at the various periods post-freezing, as indicated by a significant interaction between period × Bulls/lines.

PERMANENCY OF CONFORMATION SCORES PLACED ON BEEF HEIFERS. Martin J. Burris and B. M. Priode, *Virginia Agricultural Experiment Station and U.S.D.A.*

Conformation scores were placed on 29 Shorthorn, 38 Hereford, and 35 Angus heifers (Jan.–May 1954 calves) by 3 judges scoring independently on 3 occasions (July 1954, Sept. 1954, and March 1955). To maintain independence between judges, there was no discussion of scoring level or of individual animals until all animals were scored. The scores were based on a scale in which an increase of 3 points indicated one grade increase in conformation. Sources of variation in scores, the pooled estimate (three breeds) of their variances, and the ration of these variances to the total were: judges, .178 (.055); times, .137 (.043); calves, 1.444 (.450); judges × times interaction, .058 (.018); judges × calves interaction, .185 (.058); times × calves interaction, .582 (.181); and judges × times × calves interaction plus error, .624 (.195). In addition to differences between calves ($P < .01$) and calf × time interactions ($P < .01$) in all three breeds the following sources of variation were also statistically significant: the Angus group; judges ($P < .01$) and times ($P < .01$); the Shorthorn group, interactions of judges × times ($P < .01$) and judges × calves ($P < .01$); and the Hereford group, judges ($P < .05$), and interactions of judges × times ($P < .05$) and judges × calves ($P < .05$). The repeatability of calves' scores for each breed was: Shorthorn, 0.343; Angus, 0.671; and Hereford, 0.463. From these observations it would appear that the conformation score placed on a calf between 5 and 13 months of age is fairly consistent but individual animals may change considerably over this range of age.

THE RELATIONSHIP BETWEEN BIRTH WEIGHT, WEANING WEIGHT AND FEED LOT GAIN IN BEEF CATTLE. T. C. Cartwright and B. L. Warwick, *Texas Agricultural Experiment Station.*

Birth weights, 180-day adjusted weaning weights, and gains during 140 or 154-day feed lot periods were available from 723 calves born from 1951 through 1954. Represented were the Hereford, Brahman, Santa Gertrudis and Red Poll breeds and various crosses among these. Ranges were: 2 to 15 years for dam age, 37 to 115 lb. for birth weight, 146 to 560 lb. for weaning weight and 0.7 to 3.3 lb. feed lot gain. Birth weight, weaning weight and feed lot gain were analyzed within year, ration, sex, age of dam and breed or cross. All animals were given as equal opportunities as possible except for three months when cattle were in breeding pastures. Simple intra-class correlation coefficients were: birth weight — weaning weight = .31, birth weight — feed lot gain = .25 and weaning weight — feed lot gain = .28 (each $P < .01$). With feed lot gain as the dependent variable and the two earlier weights as independent variables, the multiple correlation coefficient was .33. It appears that these variables are related as expected since they are all measures of growth at various stages. The predictive value of the two earlier measurements taken singly or together is small. Within the limits of this study, selecting for growth at any one stage is not antagonistic to selection at another stage.

THE EFFECT OF DAY AND FREQUENCY OF MATING ON CONCEPTION RATE AND LITTER SIZE IN SWINE. J. V. Craig, H. W. Norton, P. R. Rio and John F. Lasley, *University of Illinois and University of Missouri.*

The influence of single mating on day 1 or 2 of heat or of double mating (days 1 plus 2, by the same boar) on rate of settling and on litter size farrowed have been analyzed for 402 females bred in seven seasons and for 197 litters farrowed in four seasons, respectively. Day 1 vs. day 2 single matings resulted in about the same percentage of females conceiving for 153 females bred in four seasons. Data for single matings were therefore pooled for seven seasons (including three seasons with day of single mating unspecified) and compared with double matings. A significant ($P < .01$) interaction for season-breeding-groups with frequency of mating was found. The over-all unweighted difference revealed a conception rate 14 percentage points higher for double matings, which was significant ($P < .05$) when compared with the interaction term. Study of total litter size farrowed indicated significant interactions within one of four seasons of breeding-groups and of seasons with day of single service. The unweighted (non-significant) difference between days of single service was 1.0 pig in favor of day 1. Since the optimum time of single mating varied among breeding-groups and from season to season, litter size data for single matings were not pooled. Weighted mean differences (non-significant) for total litter size farrowed were in favor of double mating by 0.1 pig as compared to day 1 and 0.6 pig as compared to day 2 matings.

COMPARISON OF MEASUREMENTS AT BIRTH, AT SIX MONTHS, SIX MONTHS GAINS, AND THE RELATIONSHIP OF THE SIX MONTH MEASUREMENTS TO BIRTH, FOR HOLSTEIN, AYRSHIRE, GUERNSEY AND JERSEY FEMALES AND MALES. H. P. Davis, *University of Nebraska.*

Weight, thickness of the skin, and thirteen linear measurements as follows: heights—at withers, at hooks, at pin bones; lengths—diagonal, body, rump; widths —of chest, of hooks, of pin bones; depths of chest and barrel; and chest and barrel girths, were taken at birth and at six months, for Holstein, Ayrshire, Guernsey and Jersey females and males. The six month gain and the six months measurement divided by birth were calculated for each measurement. At birth the males of all

breeds tended to exceed the females. At six months, Holstein and Guernsey males had greater measurements than their respective females, and Ayrshire and Jersey females tended to be larger than their respective males. In many instances these differences were small. Daily weight gains for the first six months were as follows: Holstein females, 1.71 lb., males, 1.86 lb.; Ayrshire females, 1.45 lb., males, 1.32 lb.; Guernsey females, 1.27 lb., males, 1.41 lb.; Jersey females, 1.26 lb., males, 1.20 lb. Six month measurements divided by birth measurements, for the thirteen linear measurements combined yielded the following: Holstein females, 1.636, males, 1.639; Ayrshire females, 1.644, males, 1.575; Guernsey females, 1.608, males, 1.622; Jersey females, 1.707, males, 1.705; and for weight—Holstein females, 4.53, males, 4.39; Ayrshire females, 4.35, males, 3.96; Guernsey females, 4.25, males, 4.53; and Jersey females, 5.23, males, 4.82. Growth in the various body areas was much alike for the males and females of the same breed, and between breeds. The Jersey males and females grew more rapidly, as measured by relationship to birth, than the other breeds.

EVALUATING BEEF AND DUAL-PURPOSE CATTLE BY THE PROPORTION OF WEIGHT CARRIED ON THE FRONT AND HIND LEGS. W. M. Dawson, R. L. Hiner and L. L. Madsen, *Animal and Poultry Husbandry Research Branch, U.S.D.A.*

At the Agricultural Research Center, Beltsville, Md., an attempt has been made to determine whether the proportion of weight carried by the front and the rear legs of live beef and dual-purpose cattle could be used in evaluating them. Thirty-six animals (20 milking Shorthorns and 16 beef animals) were weighed just before slaughter, first on a single scale to obtain their total weight and then on two scales simultaneously with their front feet on one scale and their hind feet on another, to obtain the weight carried by the front and hind legs, respectively. The weight carried on the hind legs averaged 43.55 percent with a range from 41.37 to 45.66 percent of the live weight just previous to slaughter (animals off feed but not water for 24 hours). A correlation of + 0.66 was obtained between the percent of the live weight carried by the hind legs and the percent of the empty body weight contained in the hind quarters. (Empty body weight is the slaughter weight minus contents of the digestive tract.) There was a marked difference between beef and dual-purpose animals in both the proportion that the hind quarters were of the empty body weight and the proportion of weight carried on the hind legs, but the correlation between these characters was practically the same for both groups. The relationship did appear to be somewhat related to the fatness of the animals.

REPEATABILITY OF A SUBJECTIVE TYPE SCORE FOR BEEF CATTLE. C. A. Dinkel, *South Dakota State College.*

A study of the repeatability of 1650 type scores on 236 cows was conducted at the South Dakota Experiment Station. The method of classification consisted of scores of one through six with further subdivision allowed by the use of plus and minus on each of the scores. In actual practice the scores five and six were seldom used and the classification was essentially that of 12 possible scores. For analytical purposes the scores were coded from zero to 17 with the best possible score 1+ receiving 17. The scores used were the average of all judges scoring that particular day and for the most part represent three opinions; however, on a few occasions only one or two judges were available. All cows, both purebred and grade, scored at least two consecutive years on the same substation were included in the analysis. Once a cow was moved from one station to another she was eliminated from the study. Repeatability was measured by the intraclass correlation among scores on the same cow. The analysis was conducted on a within year-age

group basis in order to eliminate both year and age of cow effects. The repeatability of this scoring system, calculated in this manner, was .33 with the upper limit at .41 and the lower at .24. The correlation of the type score at one year of age with the average of all subsequent scores was .55 with 155 degrees of freedom.

ALTERNATE ADMINISTRATION OF PROGESTERONE AND DIETHYLSTILBESTROL IN HORMONALLY INDUCED LACTATIONS. P. J. Dziuk, J. H. Koshi and W. E. Petersen, *University of Minnesota.*

The hormones were administered subcutaneously in a 1 or 2 percent corn oil solution. Cow 342, a sterile multiparous Jersey, was given 30 mg. of diethylstilbestrol (DES) every third day to induce lactation. Other hormones, including growth hormone, prolactin and progesterone were used during the lactation. A total of 431 lb. of butterfat was produced in 305 days in this lactation. A second attempt with this schedule gave no response. A third attempt with cow 342 and two other cows; 361, a sterile nulliparous Jersey and 973, a Holstein freemartin, was made using the following treatment. Four days of 20 mg. of DES daily were followed by four days of 100 mg. of progesterone daily. This cycle was repeated. 342 was injected a total of 106 days, 361 for 178 days and 973 for 132 days. Milking was started 42, 35 and 53 days after the first injection, respectively. The rate of increase of production per day and the peak daily production was as follows: 342, .37 lb. and 32 lb.; 361, .2 lb. and 18 lb. and 973, .66 lb. and 40 lb. T68, a sterile Guernsey, and 956, a Holstein freemartin, received 20 mg. of DES on alternate days for 30 days followed by 30 days of 30 mg. of DES every third day with 50 mg. of progesterone daily during the final 12 days of the last month. T68 produced 143 lb. of butterfat, which was 66 percent of her identical twin mate's production for the same but natural lactation. 956 produced 101 lb. of butterfat in 163 days. Neither T68 nor 956 responded to a repeated similar treatment. A nonbreeding Holstein, 932, given DES and progesterone at the rate of 10 and 40 mg. respectively every fourth day for 30 days produced 255 lb. of butterfat in 300 days.

USING THE PROBING TECHNIQUE IN SELECTING BREEDING SWINE ON FARMS. Ralph M. Durham and John H. Zeller, *A.R.S., U.S.D.A.*

A study was conducted on the use of the live probe to identify superior swine breeding stock on midwest swine breeding farms. Herds were located in Illinois, Indiana, Wisconsin, Ohio, and Pennsylvania. Twenty-nine herds of purebreds, representing eight breeds, and one crossbred herd, were in the study. One of the objectives was to determine the farmer reaction to the probing of registered swine,

The six inch metal ruler probe was the tool used in the work. Probing was done at three sites: (1) Behind the shoulder, one inch posterior to a line drawn perpendicular to the front elbow; (2) at the juncture of last rib and vertebrae; (3) perpendicular to the stifle joint. The incision was from two to three inches lateral to the midline, depending on the size of the hog, and the probe was angled slightly to the center of the animal's body. Penetration of the false lean at the shoulder site was accomplished. Hogs weighing from 140 to 280 lb. are included in the study.

Eleven hundred animals were probed and weighed, including both spring and fall farrowed pigs. Good farmer reaction was encountered and no difficulties with infections were observed. A significant sex difference was found, with boars being the leanest and barrows the fattest of the three sexes. Factors for adjusting backfat thickness to a constant weight have been developed from the data, and these factors will be presented.

INFLUENCE OF AGE OF CALF, SEX AND AGE OF DAM ON WEANING WEIGHT IN HEREFORDS. Lee E. Evans, J. V. Craig, G. F. Cmarik and R. J. Webb, *University of Illinois.*

Weaning weight adjustments for age of calf, sex and age of dam were obtained from data on 1737 purebred and grade Hereford calves raised in the Dixon Springs Experiment Station herd over the period 1944 through 1953. All bull calves were kept until weaning without castration in the purebred herd, whereas bull calves were castrated at birth in the grade herd. Sex and age of calf effects were calculated on a within herd, sire and age of dam basis. Bull calves averaged 6.1 percent or 22 lb. heavier ($P < .05$) and steers 4.1 percent or 17 lb. heavier ($P < .05$) than heifers in the purebred and grade herds, respectively. All heifer weights were adjusted to male equivalents. Regressions of weight on age of calf at weaning differed significantly ($P < .05$) between the purebred and grade herds, amounting to 0.908 and 1.080, respectively Prediction equations used for adjusting weaning weights to a standard age of 210 days were: $\overline{W} = 425w/(X + 215)$ for purebreds and $\overline{W} = 342w/(X + 132)$ for grades, where $\overline{W}$ is the adjusted weight, w is the actual weight and X is the actual age of the calf. Cows reached maximum production, as measured by calf weights, at 5 through 8 years of age. Mature cow equivalent calf weights were obtained by adding 106, 54, 20, 0, 0, 0, 0, 14 and 43 lb. to calf weights from dams 2, 3, 4, 5, 6, 7, 8, 9 and 10 years of age, respectively.

THE RELATIONSHIP OF SERUM ALKALINE PHOSPHATASE TO SUBSEQUENT GAIN IN BRAHMAN CATTLE. J. L. Fletcher, R. R. Shrode and H. O. Kunkel, *Texas A. & M. College.*

The usefulness of serum alkaline phosphatase activity as an index of future gain was investigated in four groups of Brahman cattle. Three of the groups were on record of performance test at the Bluebonnet Farm of the Texas Agricultural Experiment Station. The fourth group was maintained under ranch conditions. The efficiencies of prediction of gain based on a knowledge of initial age, initial weight and serum phosphatase were compared. Serum phosphatase was equal or superior in efficiency to either of the other variables. In the three groups on performance test maximum efficiency of prediction was secured by utilizing the three variables. In the ranch group the inclusion of phosphatase in the prediction equation did not improve upon an equation in which only age and weight were involved.

DESOXYRIBOSE NUCLEIC ACID (DNA) CONTENT OF GERMINAL CELLS IN BOVINE TESTES. N. S. Fechheimer, M. A. Lessler and L. O. Gilmore, *The Ohio State University.*

The testes of ten young (approx. 1 year old) bulls were studied by quantitative cytochemical techniques. Determinations of the DNA content of whole nuclei of spermatogonia, primary spermatocytes and spermatids were made by cytospectrophotometric techniques. Samples of excised testes were fixed in 10% formalin; sections cut at 15 microns (to insure whole nuclei) and stained by means of the Feulgen technique. The nuclei of spermatogonia, primary spermatocytes and spermatids showed mean relative amounts of DNA of $12.2 \pm .07$, $27.1 \pm .19$ and $6.7 \pm .07$, respectively. A section of liver was placed on each slide as a control. Mean values for two classes of liver nuclei measured 12.1 and 24.0. These values are comparable to those for spermatogonia and primary spermatocytes which therefore are assumed to represent the DNA equivalents of diploid and tetraploid chromosome numbers. Preliminary analysis reveals that the variances of the testicular cell types were not homogenous ($P < .01$). There were also significant differences between bulls in the variances of the spermatids and primary

spermatocytes ($P < .01$), but not of the spermatogonia ($P > .05$). There were no differences in the mean DNA values between bulls for each of the 3 testicular cell types measured. These results suggest that meiosis in young bulls is somewhat irregular.

EFFECT OF MILK-GLYCINE AND EGG YOLK-GLYCINE DILUENTS ON THE SURVIVAL OF BOVINE SPERMATOZOA. R. J. Flipse and J. O. Almquist, *The Pennsylvania State University.*

These studies were undertaken to determine the effect on spermatozoan livability of adding glycine solutions to a diluent prepared by reconstituting nonfat dry milk powder. In the first trial, equal volumes of heated skimmilk and glycine solution of from 0.06 to 1.00 M were used. Spermatozoa survived 22 days in milk—0.5 M glycine compared to 14 days in heated skimmilk alone. In subsequent trials cysteine-treated skimmilk-glycine was tested, and additions of fructose, arginine, glycerol, and lipo-protein were made in attempts to further improve spermatozoan livability. Motility was maintained longest in the milk-glycine diluent to which glycerol was added. During the first week of storage, milk and the better milk-glycine diluents supported motility equally as well, but after the 8th day average motility was maintained at a higher level in milk-glycine than in milk. Egg yolk—0.5 M glycine (1:1) supported motility better than did milk-glycine, particularly during the second week of storage. Tests of fructose utilization and of lactic acid production revealed no pronounced effect of glycine upon glycolysis. Semen was incubated in milk-glycine containing uniformly labeled glycine-C^{14} and the uptake of radioactivity observed. Some C^{14} remained in the spermatozoa after repeated washings, and the CO_2 produced during incubation had a specific activity of 117 counts per minute per micromole showing glycine utilization.

A STUDY OF THE BREEDING BEHAVIOR IN A GROUP OF WESTERN EWES. A. W. Gardner, T. Donald Bell and Walter H. Smith, *Kansas State College.*

A three-year study of the breeding behavior in a flock of approximately equal numbers of Southwest whiteface, Northwest whiteface, and Northwest blackface ewes, was conducted to determine the occurrence of estrus, the extent of lactation anestrum, and the repeatability of lambing date. The ewes were bred for fall lamb production. Intact yearling rams of the Hampshire, Suffolk, Southdown, and Shropshire breeds were placed with the ewes during early June. After these rams were removed, vasectomized Rambouillet rams were placed with the ewes to ascertain the occurrence of estrus. Records showed that considerable breeding activity occurs in all months of the year except for a period from approximately January 15 to March 31, with the Southwest ewes showing first estrus followed by Northwest blackface and Northwest whiteface ewes. A small percentage of the ewes were receptive to vasectomized rams within 48 hours after lambing. Other than this, the lactation anestrum appeared to last for 5 to 7 weeks, after which some ewes were receptive to the rams. However, indications of regular heat were not observed until approximately two weeks after the lambs were weaned. The repeatability study consisted of correlating three annual lambing dates. When a correction was made for ewes and rams, an average correlation of .433 (NS) was obtained. With no correction for rams, a correlation of .349 for interbreed groups, and a correlation of .272 (NS) for breed groups was obtained.

THE GENETIC RELATIONSHIPS OF PHENOTYPICALLY DIFFERENT BOVINE DWARFS. P. W. Gregory, *University of California.*

F_1 progeny were produced from crossing 4 phenotypically different recessive dwarf type. The dwarf stocks used were: (1) Hereford (Johnson *et al.*, 1950); (2) Angus (Baker *et al.*, 1951); (3) Shorthorn (Gregory, unpublished); and

(4) another Shorthorn dwarf characterized by a heavy body with short legs (Gregory, unpublished). Crosses between the Hereford and Angus dwarfs yielded 2 distinct types of offspring, short-headed dwarfs and phenotypically normal that mature early and resemble comprest animals in size. The Shorthorn (3 above), crossed with the Hereford produced 5 phenotypically normal progeny which mature early and resemble comprest; when this Shorthorn was mated to an Angus dwarf, one short-headed dwarf and one phenotypically normal animal of comprest type was produced. The remaining Shorthorn dwarf (4 above), was mated to normal Hereford heifers some of which were known to be heterozygous for the dwarf gene and produced dwarfs of the short-headed type and phenotypically normal progeny that cannot be classified further until maturity. The genetic relationships of these 4 dwarf types cannot be determined with certainty until conclusive results are obtained from other critical mating tests. The results clearly indicate that more than one pair of genes is involved in the production of different morphological forms of dwarfs. The 4 different forms of dwarfs appear to be conditioned by the same recessive gene and further phenotypic differentiation may be conditioned by specific genes that act as modifiers. Separation of the different dwarf types seems to be rather complete with little over-lapping. These results suggest a possible relationship of comprest with the common type of dwarfism.

PRELIMINARY OBSERVATIONS ON THE DEVELOPMENT OF THE NORMAL BOVINE EMBRYO FROM THE LATE BLASTOCYST STAGE TO THE DIFFERENTIATION OF ORGAN PRIMORDIA. Julius S. Greenstein and Richard C. Foley, *University of Massachusetts.*

These preliminary results are based upon timed embryos recovered from cattle with normal reproductive histories. At least two specimens representing each day of development from 16 to 22 days were studied. By 16 to 17 days, the blastocyst with its raised, oval germinal disc, underwent a variable degree of elongation extending rapidly throughout the gravid horn. Entodern completely lined the trophoblast while the mesoderm had split to form extraembryonic somatopleure, splanchnopleure, and coelom. The chorionic vesicle of the 18- to 19-day blastocyst extended at times into the nongravid horn. An undercutting of the embryonic area marked the future body stalk and accentuated the flexure of the body contour. The primitive streak established the longitudinal axis and the ectodermal plate, neural folds, sinus rhomboidalis, and a few somites could be identified. The notochord extended cephalad from a prominent Hensen's node. At 20 days, rapid development of the endocardial tubes and associated heart primordia contributed to the formation of the first entraembryonic coelom. Amnion completely enclosed the embryo. The 21-day embryo exhibited a neural tube at the level of the first somites, a liver primordium, differentiation of the gut regions, and a double-walled tubular heart suspended mesially. The embryo at 22 days was identified easily by a beating heart, otic invagination, optic vesicle, mandibular arch, yolk sac, and allantois. As additional embryos become available, more precise information relative to the developmental patterns and range of variation among normal embryos may provide some clues to causes of early embryonic mortality.

THE RELATIVE IMPORTANCE OF VARIOUS LIVE-HOG MEASUREMENTS IN PREDICTING CARCASS VALUE. C. J. Heidenreich, J. F. Lasley, D. E. Brady and L. F. Tribble, *University of Missouri.*

Data on 81 Landrace-Poland-Duroc crossbred hogs slaughtered in the fall and winter of 1953–54 and 118 Landrace-Poland crossbreds slaughtered in the fall and winter of 1954–55 were studied to determine the relative value of certain body measurements for predicting (a) the percent liveweight of fat, (b) percent live-

weight of the five-primal cuts, and (c) the adjusted loin equivalent as percent of liveweight. The six live-hog measurements used were: backfat probe at the shoulder, hip, and ham; body length; circumference at the heart girth; and flank circumference. Individual multiple regression analyses were made for each of the two crosses. By designating the percentage of fat, percentage of five primal cuts, and adjusted loin equivalent as dependent variables, and the six live-hog measurements as independent variables, net regression coefficients and estimating equations were calculated. In both crosses, the live-hog measurements studied were the most useful in explaining variance in the percentage of fat as indicatd by R^2 values of .51 and .60 in 1953–54 and 1954–55, respectively. Beta coefficients were calculated to determine the relative contribution of each live-hog measurement in reducing residual variance in carcass measurements. Significant breed differences were obtained in this respect.

THE INSULIN-GLUCOSE TOLERANCE TEST AS APPLIED TO PHYSIOLOGICAL STUDIES IN BEEF CATTLE. C. J. Heidenreich, J. F. Lasley and J. E. Comfort, *University of Missouri.*

A test, such as the insulin-glucose tolerance test, in which an animal is placed under metabolic stress is useful in determining the performance of endocrine glands influencing metabolism and illustrates disturbances in homeostatic response. Hereford cattle were subjected to such a test to ascertain whether or not any observable differences in response were apparent. Nine calves, including dwarf and normal appearing individuals, were studied. The average initial blood sugar level of four normal calves was 81.2 mg. percent with maximal blood sugar levels observed thirty minutes after glucose injection (211.2 mg. percent). Tolerance curves of dwarf calves were not of a consistent pattern. Blood sugar values obtained on dwarf M1 were as follows: initial, 78.1 mg. percent; thirty minutes following glucose injection, 280.1 mg. percent. Another dwarf, 355, exhibited marked increase in glucose tolerance as indicated by a maximal blood sugar value of 136.7 mg. percent with an initial value of 77.0 mg. percent. These two calves showed extreme (an antithetical) type curves. Three other dwarf calves were studied, each of which exhibited a tolerance curve intermediate to those mentioned. Tolerance tests were also conducted on ten mature cows. No apparent difference in metabolic response was noted between dwarf carrier and non-carrier cows. Lactating cows, however, showed a decreased tolerance to glucose when compared with non-lactating individuals.

IMPROVEMENT OF CATTLE THROUGH ARTIFICIAL INSEMINATION—THE NATIONAL PICTURE. H. A. Herman, *National Association of Artificial Breeders.*

The improvement of cattle by means of artificial insemination marks a new development in the mass use of proved sires. Its ramifications are comparable only to the use of hybrid seed corn. In 1939 there were 7,539 cows in 646 herds enrolled on the organized program in the United States but by the end of 1954 there were 5,155,240 cows in 593,190 herds enrolled. This is about one out of every five milk cows. Throughout the world the percentage for A. I. ranges from 14 percent in France to 75 percent in Denmark. Prior to 1937 about 10 percent of the dairy sires in use were proved but in 1954 36.7 percent of the sires in artificial insemination were proved with an average of 11,176 lb. milk, 473 lb. butterfat on their daughters. This is about 1,600 lb. of milk and 70 lb. of butterfat above the average D.H.I.A. proved sire. In 1939 only 228 cows were bred per sire in A. I., but in 1954 this ratio was 1:1937. About 12 percent of the cows serviced by A. I. are registered, but from 20 to 61 percent of the new breeders get their start from A. I. About 4 to

5 percent of the cows are inseminated with beef bull semen. Frozen semen, making it possible for a single sire to father 50 to 75 thousand calves per year, has entered the picture. The effect of these developments on the number of sires involved, transmission of inherited and lethal defects, and the position of the purebred breeder will be discussed.

CROSSBREEDING IN BEEF CATTLE. Leroy H. Holt, *University of Minnesota.*

The results from 22 published experiments in crossbreeding beef cattle were appraised. These covered British breeds, other European breeds, zebus, and unimproved cattle. Croosbred beef cattle had an average of 4.35 percent heterosis in weight and growth rate. Zebu-European calves were 30 percent heavier at birth than the parental breed average, and British beef breed crosses were 3 percent heavier at birth. Crossbred calves averaged 3.5 percent above the parental average in weaning weight. Crossbred cattle averaged 3 percent heavier in finished weight than the parental breeds. Brahman crosses dressed out 2.6 percent higher than the parental average. Crosses between common beef breeds consistently display hybrid vigor in measured productive traits, and the wider crosses show the greater heterosis. Crossbreeding gives a quick increase in productivity of beef cattle.

THE RELATION OF BLOOD GLUTATHIONE LEVEL TO GROWTH AND BODY SIZE IN BEEF CATTLE. J. F. Kidwell, M. A. Wade and J. E. Hunter, *University of Nevada.*

Blood level of GSH, weight, heart girth, hemoglobin, total cell count, and rate and economy of gain during an 84-day feeding trial was determined for 47 Hereford steers. No relation was observed between blood GSH and weight, or rate of gain. A small correlation was observed between blood GSH and subsequent economy of gain and between blood GSH and heart girth. The blood level of GSH was correlated with hemoglobin and with total cell count. A significant difference between the blood level of GSH at the beginning and at the end of the 84-day period was noted. There was a small correlation between blood GSH determined at the beginning of the trial and at the conclusion. It is suggested that differences in the plane of nutrition may be important. It is concluded that the level of whole blood GSH is not useful in a selection program for rate and economy of gain and body size.

ESTIMATES OF HERITABILITY OF RATE OF GAIN IN BEEF CATTLE. C. M. Kincaid and R. C. Carter, *Virginia Agricultural Experiment Station.*

Estimates of heritability of rate of gain were obtained from progeny tests of bulls selected for fast and slow gains in comparative feeding tests over a five year period. Groups of young beef bulls were individually self-fed for a period of 168 days following weaning. The 118 bulls on test during the five years had an average daily gain of 1.94 lb. per day. A total of 18 bulls selected for fast gains averaged 2.22 lb. per day while 18 slow gaining bulls gained 1.66 lb. per day. The difference, 0.56 lb. per day, was twice the standard deviation of the entire group. The selected bulls were paired (one fast and one slow-gaining bull) within breed and age group for mating in the progeny tests. Cows from a test herd of grade Herefords were allotted at random in equal numbers from within sets of half-sibs to each of a pair of bulls. The steer progeny, totalling 170 head, were individually self-fed for 200 days. The heifer progeny (188 head) were wintered largely on roughage and grazed on bluegrass pasture their yearling summer. Average differences in daily gain between the progeny of the fast and slow gaining sires were .087 lb. per day for the steer's feed lot gain and 0.58 lb. per day for the heifer's gain on pasture.

Heritability estimates for daily gain, based on these average differences, were 31 and 20.8 percent for the steers and heifers, respectively. The 6 months weight of the steer and heifer progenies of the fast gaining bulls averaged 9 and 20 lb. greater, respectively, than the progenies of the slow gaining bulls. The genetic correlation based on parental half-sib analysis of weight at 6 months and daily gain in feedlot or on posture was .69 and .51 for steers and heifers, respectively.

WEIGHT INCREASE WITH AGE OF NON-CARCASS TISSUE AND OFFAL AS A MEASURE OF GROWTH IN BEEF CATTLE. C. M. Kincaid, *Virginia Polytechnic Institute.*

In this study non-carcass tissue and offal, designated here as offal, was obtained as the difference between final experimental liveweight and hot carcass weight. The data were averages of groups of beef steers (524 head in all) in feeding and grazing experiments over a 15-year period. Experimental periods prior to slaughter were usually 12 months for those finished on pasture and 6 to 8 months for those finished in drylot. In those experiments where liveweight gain was significantly influenced by different feeding treatments carcass weight was increased by about the same amount, but offal weight was almost unchanged. In one test two groups of pasture fattened steers slaughtered at 42 months of age had average final liveweights of 1428 and 1376 lb.; carcass weights of 829 and 773 lb.; and offal weights of 599 and 603 lb., respectively. In general offal weight followed a definite pattern of increase with age that was influenced very little by year or level of nutrition. Estimates of average of offal weight for ages of 12, 18, 30 and 42 months of age turned out to be 305, 405, 525 and 585 lb., respectively. The data indicated that for beef steers growth of offal with time may provide a basis for estimating carcass increases due to different experimental treatments and thus provide a way to measure more precisely the real value of gain. It is concluded from these data that where the animals are at least 8 months old and level of nutrition at least slightly above maintenance the weight of offal follows a definite trend with age which can be used with fair precision to separate liveweight at a given age into two components, carcass weight and non-carcass weight.

FORMS OF DWARFISM IN ENGLISH AND BRAHMAN BREEDS OF BEEF CATTLE. M. Koger, J. C. Dollahon, A. C. Warnick, W. G. Kirk, J. F. Hentges and A. Z. Palmer, *Florida Agricultural Experiment Station.*

Observations have been made on the different forms of dwarfism which occur in the various breeds and strains of beef cattle in Florida. They include Angus, Hereford, Shorthorn, Brahman and cattle of various combinations of breeds. In this study, animals under good management and nutrition that remained distinctly subnormal in size were considered dwarfs, irrespective of longevity, health and vitality. General appearance and various anatomical proportions were used for classification. The following types have been encountered in sufficient numbers to be considered as distinct groups: "Snorter" type Hereford dwarf; dwarfism in Angus apparently the same as "Snorter" in Herefords; "Long-headed" Angus; "Comprest" in Herefords. The above types occur widely and have been reported previously. "Ant-eater" type Angus, which are characterized by a long pointed nose are phenotypically distinct from the "Long-headed" type. This condition apparently is inherited, but irreversible environmental influences may be involved. "Long-headed" dwarfs in Herefords and Shorthorns have a similar phenotypic syndrome, but distinct from the "Long-headed" Angus. It is similar in many respects to "Stumpy" described in Shorthorns. Inheritance is apparently recessive. "Midgets" in Brahmans are small compact animals. Mode of inheritance is apparently recessive or incompletely dominant with variable penetrance. "Guinea" in crossbred

and Florida native cattle are similar in appearance to "Comprest" Herefords and "Midget" Brahmans. The mode of inheritance is either a dominant or an incomplete dominant, but apparently is a different gene than "Comprest" in Herefords.

THE EFFECT OF BIRTH WEIGHT, AGE OF DAM AND TIME OF BIRTH ON SUCKLING GAINS OF BEEF CALVES. G. E. Nelms and Ralph Bogart, *Oregon State College.*

One hundred three purebred Hereford and Aberdeen Angus calves were used in the study. The data include two years—1953 and 1954. Time of birth was broken down arbitrarily, into 20-day periods beginning with March 1. The other variables were used in the usual manner. The data were analyzed using the least square analysis. Lines, time of birth, and birth weight had significant effects on suckling gains. The regression of suckling gains on birth weight was 0.0115. The effect of age of dam only approached significance. The effect of sex was not significant. This would indicate that on removal of the birth-weight effect, the females approached the males in suckling gains.

THE EFFECT OF BREED OF SIRE ON DIMENSIONS OF LAMBS AT BIRTH. W. E. Neville, Jr., A. L. Pope and A. B. Chapman, *University of Wisconsin.*

Over a period of two years, 30 rams (10 each of Hampshire, Suffolk and Shropshire breeds) were bred to 72 western ewes which produced 92 crossbred lambs. Ewe measurements at lambing included width at hips and pins with no significant difference between sire groups. Lamb measurements in birth position included birth weight; width of head and shoulder points; height at shoulder points and chine; circumference at shoulder points and chine; length of head and height of head on knees. None of the ewes had lambing difficulty that could be attributed to the breed of the lamb's sire. In 1955, the Suffolk males were sig. heavier at birth and had sig. larger shoulder circumference than Hampshire and Shropshire males, the latter two groups showing no difference. These two measurements did not differ among female group in 1955 or among male and female groups in 1954. Other than head length, no important difference was found between Suffolk and Hampshire sired lambs in 1954 but both these groups differed from the Shropshire group in head width. For head width in 1955, only the Suffolk male group differed from the Shropshire male group. There was no sig. difference in lamb measurements due to its being a single or twin. In almost every case, the male measurement was larger than the female.

RELATIVE GROWTH RATES AT 80° AND 50° F. OF SANTA GERTRUDIS, BRAHMAN, AND SHORTHORN HEIFERS. E. B. O'Bannon, P. R. Cornelison, A. C. Ragsdale and S. Brody, *University of Missouri.*

Brahman heifers grew more rapidly under a constant environmental temperature 80° F. than at 50° F. Santa Gertrudis grew equally well at 50° and 80° F.; Shorthorns grew 40 to 50 percent more rapidly at 50° F. than at 80° F. The breed differences in growth rate were closely associated with breed differences in structural peculiarities that gave the more tolerant breeds a larger surface area per unit weight and larger vascularity of some organs. The Brahman and Santa Gertrudis had short, sleek, reflective hair which did not interfere with convective or radiative heat dissipation whereas the Shorthorn had heavy, woolly, dull hair which seriously interfered with heat dissipation as indicated by a drop of 1.5° F. and .6° F. at 6 and 9 months of age, respectively, in rectal temperature by close clipping of the heifers in the 80° F. chamber. The Brahmans have very large pendulous ears, dewlap, and navel flap and especially very large, very vascular, crinolated,

hairless vulva. These appendages were somewhat smaller in the Santa Gertrudis. Since the surface temperature of the vulva was higher than of any other surface, it served as an excellent heat radiator. The rectal temperature of the Shorthorn at 80° F. was normally 2° F. above that at 50° F. The rectal temperature of the Brahman and Shorthorn were virtually identical at 50° F. Slides will illustrate these statements.

SOME ENVIRONMENTAL FACTORS AFFECTING LITTER SIZE IN SWINE. V. Rathnasabapathy, J. F. Lasley and D. T. Mayer, *University of Missouri.*

A study of 114 gilts, to determine some factors affecting litter size in swine, revealed that 95 percent of the embryonic mortality occurred during the first one-half of gestation. Factors such as weaning weight, 154 day weight and breeding age, which had significant positive correlations with ovulation rate, had more or less similar relationships with mortality but were not too closely related to litter size at 55 days of gestation. On the other hand, the length of the uterus was significantly correlated ($P < .01$) with the number of normal embryos present at the 55th day of gestation; and the uterine space occupied by each embryo was associated similarly with the weight of that embryo. This emphasizes the need for optimum spacing in the uterus for embryonic growth and survival. Since significant breed and family differences in ovulation rate, mortality and litter size existed, it was postulated that the uterine environment itself is genetically controlled. The length of the gravid uterus at 55 days of gestation was proportional to the initial length of the uterus at 200 lb. body weight. It is therefore shown that, whereas the weaning and 154 day weights of gilts may be of importance in selection for ovulation rate, the development of a method of selection for a larger uterine capacity might facilitate the development and survival of more fetuses to term.

THE ASSOCIATION OF FEMININITY RATINGS WITH AGE AT SEXUAL MATURITY, OVULATION RATE AND LITTER SIZE IN GILTS. P. R. Rio, J. V. Craig and H. W. Norton, *University of Illinois.*

Femininity ratings were assigned to 67 Yorkshire, 30 Hampshire and 73 Hampshire-Yorkshire crossbred gilts by averaging the individual scores given by a committee of three experienced judges. Each gilt was given a head rating and a total body rating on a scale from 1 to 12, with 1 as most feminine. The ova shed were counted for 46 ovulations by Yorkshire gilts and 38 by crossbred gilts. Total litter size and number farrowed alive were recorded for 15 Yorkshire, 22 Hampshire and 26 croosbred litters. Age at sexual maturity (1st heat) was not associated with head or total femininity rating as indicated by non-significant correlations of 0.01 and 0.02, respectively. Correlations of ratings with number of ova shed and with litter size farrowed did not differ significantly between breeds and were pooled. Partial correlations, independent of 154-day weight, age at judging, age at sexual maturity and heat period in which mated, were calculated. For number of ova shed with head and total rating, they were 0.10 and 0.33 ($P < .01$), respectively, indicating that more ova were shed by females rated as less feminine. For total litter size they were -0.25 and -0.19, respectively. They were -0.35 ($P < .01$) and -0.21, respectively, for number farrowed alive. The ratings used are evidently of little value for predicting farrowing performance.

EFFECT OF EGG YOLK AND ITS ISOLATED CONSTITUENTS UPON THE DEHYDROGENASE ACTIVITY OF BOVINE SPERMATOZOA. John T. Smith, Dennis T. Mayer and Chas. P. Merilan, *University of Missouri.*

Numerous literature reports and previous work at this station have shown the beneficial effects of egg yolk and its isolated constituents upon spermatozoan viability and metabolism. The importance of the dehydrogenases in spermatozoan

metabolism has been established, and the relationship of dehydrogenases, as reflected by the "reduction time" tests, to motility, longevity, and percent nonreturns has been reported. The purpose of this investigation was to ascertain the influence of whole egg yolk and certain of its isolated constituents upon the activity of dehydrogenases of bull spermatozoa. The enzyme activity of washed and unwashed spermatozoa in the experimental media was determined by the manometric method of Quastel and Wheatley. Whole egg yolk was found to stimulate the succinic, malic, and glyceraldehyde-3-phosphate dehydrogenase activity of bull spermatozoa. The dehydrogenase stimulating effect of egg yolk was found to be associated with the acetone-soluble fraction of the yolk and appeared to be the result of the stimulatory effect of cholesterol and of carotene upon succinic dehydrogenase activity. Cholesterol was observed to inhibit both glyceraldehyde-3-phosphate and malic dehydrogenase activity of bovine spermatozoa. The importance and possible mechanisms of dehydrogenase stimulation and inhibition by egg yolk, cholesterol, and carotene have been discussed, as well as the apparent failure of lecithin to stimulate succinic dehydrogenase activity.

EFFECTS OF SEVEN NON-GENETIC FACTORS ON BUTTERFAT PRODUCTION IN A GUERNSEY HERD. N. R. Thompson, P. M. Reaves, C. Y. Kramer and G. C. Graf, *Virginia Agricultural Experiment Station.*

Ninety-eight lactation records on 26 Guernsey cows were anaylzed for the joint effects of 7 non-genetic factors on butterfat production. A least squares form of analysis was used. All results are on an intra-cow basis. Deviations for year of calving were 30.5, 10.9, — 1.0, 4.5, — 7.6, — 11.2 and — 26.0 lb. butterfat for the years 1947 to 1953, respectively. None of these deviations were statistically significant. The effect of month of calving was curvilinar, with linear and quadratic coefficients of — 56.5 ($P < .001$) and 4.2 ($P < .001$) lb., respectively. Corresponding coefficients for age at calving were 4.28 ($P < .01$) and — 0.02 ($P < .05$). The linear regression of length of lactation on butterfat yield was 0.99 ($P < .001$) lb. per day. The effects of previous calving interval, length of previous dry period, and number of days gestation during the current lactation were not statistically significant.

THE ASSOCIATION BETWEEN MILK AND BUTTERFAT PRODUCTION AND TYPE RATINGS OF HOLSTEIN-FRIESIAN COWS. W. J. Tyler, E. L. Corley and E. E. Heizer, *University of Wisconsin.*

The H.I.R. production records and official type classification ratings of 45,111 Holstein-Friesian cows were analyzed to determine the intra-size intra-herd correlations and regressions of milk and fat production on type ratings. The final rating and eight breakdown classifications were used. The production records were adjusted to a ME 305-day twice-a-day milking basis. The 1721 herds were stratified into five groups according to the average milk production of the cows in each herd. The correlations between milk production and final rating, general appearance, dairy character, body capacity, mammary system, fore udder, rear udder, legs and feet, and rump were 0.16, 0.12, 0.25, 0.10, 0.13, 0.09, 0.14, 0.05, and 0.05, respectively. The association between fat and type ratings were similar to the values between milk and type. The regressions of milk production on the above type ratings were 392, 301, 649, 253, 300, 187, 308, 110, and 102 lb., respectively. The corresponding regressions of fat on type ratings were 15, 12, 23, 10, 12, 8, 12, 4, and 4 lb. The differences between the correlation coefficients for the stratified herd groups were small and not significant.

THE MINERAL CONTENT OF BLACK CATTLE HAIR OF TWO DIFFERENT GENOTYPES. R. G. Washburn, L. O. Gilmore and N. S. Fechheimer, *Ohio Agricultural Experiment Station.*

In an effort to associate chemical differences of cattle hair with genotypic differences the amounts of K, Na, Mg, Ca, Fe, Cu, Ba, Pb and Mn have been determined by flame photometry from the ash of selected hair samples. With the possible exception of K and Na no differences were found between samples of black hair from red carriers and from non-red carriers. This evidence indicates either that these minerals are not involved in the production of black pigmentation of cattle hair although Cu and Fe have been found to be among those involved in black pigmentation in mammals, or that the gene responsible for this pigment is completely dominant to its allele. The conclusion of mineral differences existing between black, red and white cattle hair, previously found, has been confirmed with the present samples and technique of mineral analysis.

AGE TO FIRST BREED BEEF HEIFERS. R. J. Webb, G. F. Cmarik, H. A. Cate and J. M. Lewis, *University of Illinois.*

A total of 96 yearling heifers from three successive calf crops produced in the grade Hereford herd at the Dixon Springs Station were lotted into two groups each year. Group I, lots 1, 3, 5 were bred at approximately 15 months of age. Group II, lots 2, 4, 6 were bred at approximately 27 months of age. A total of 330 matings in Group I resulted in 300 pregnancies, 273 living calves with 268 calves weaned. Two hundred ninety-two matings in Group II resulted in 272 pregnancies, 260 living calves with 246 calves weaned. Group I weaned 5.93 calves per original cow and 4.82 calves were weaned in Group II per original cow. Group I weaned 380.3 lb. calves and Group II 403.1 lb. Group I weaned 2265 lb. per cow and Group II 1913 lb. At ten years of age, 55.6 percent of the cows remained in Group I and 47.1 percent in Group II. Final weights of the cows were about the same with a slight advantage in favor of Group I. The results of this study indicate approximately one additional calf is produced by breeding beef heifers to calve first at two years of age rather than three years of age.

OVULATION, FERTILIZATION AND EMBRYONIC SURVIVAL IN VIRGIN HEIFERS, PAROUS, AND LOW FERTILITY BEEF COWS. R. S. Wilhelm, Jr., A. C. Warnick, M. Koger, A. Z. Palmer and W. G. Kirk, *Florida Agricultural Experiment Station.*

Comparisons were made of the reproductive performance in 51 low fertility Brahman cows, 12 low fertility English cows, 9 fertile parous cows and 27 two year old virgin heifers. The cows were bred to a fertile bull at the first estrus and slaughtered alternately at 3 and 34 days following breeding. This procedure gave an estimate of fertilization rate and early embryonic survival. The interval from exposure to the bull until first estrus varied from 11 to 33 days but there was no significant difference among the groups. Various types of genital abnormalities, primarily failure of ovulation, occurred in 55, 40, 0 and 19 percent of the Brahman, English, parous cows and virgin heifers, respectively. Explanation of low fertility in Brahman cows was failure of estrus 14 percent, failure of fertilization 38 percent, early embryonic death 28 percent and normal embryos at 34 days 20 percent. Low fertility in the English cows was accounted for by failure of fertilization 40 percent, early embryonic death 31 percent and normal embryos at 34 days 29 percent. The percentage of fertlized eggs in parous cows and virgin heifers was 50 percent and 39 percent, respectively. The percentage of normal embryos at 34 days was 100 percent in parous cows and 64 percent in virgin heifers. Fertilization rates were

approximately comparable in all four groups of females while embryonic death was much higher in the low fertility Brahman and English cows compared to fertile parous cows and virgin heifers.

A STUDY OF VAGINAL AND UTERINE PROLAPSE IN HEREFORD CATTLE. R. R. Woodward and J. R. Quesenberry, *U. S. Range Livestock Experiment Station, U.S.D.A.*

Vaginal and uterine prolapse constitutes a serious problem in many herds of beef cattle. The incidence appears to vary between areas and herds. A study of the occurrence of prolapse was made in the station herd for the period 1935–54. Supplemental data were obtained from another experimental herd of similar genetic origin maintained under different environmental conditions. In the herd at the U. S. Range Station the percentage incidence by years for the perod studied ranged from 0.0 to 2.7 percent of all births. The percentage incidence between age groups of cows was not significantly different statistically, but there was a trend toward a reduced incidence after the first parturition and an increased incidence after the cow reached seven years of age. There was a significant difference between lines in the occurrence of prolapse. Station effects were measured by a comparison of cases occurring in a line which was serviced by common sires at two stations. There was a statistically significant difference between the 1.7 percent incidence at one station and the 0.7 percent incidence at the other station operated under similar management procedures but differing in nutritional allowances. The specfic nutritional factors tending to contribute to prolapse were not determined but hereditary differences suggest that prolapse could be controlled to some degree by rigorous culling.

Nutrition Section

T. S. Hamilton, *Chairman*

DESSICATED SEWAGE SLUDGE AS A PARTIAL NITROGEN REPLACEMENT IN STEER RATIONS. E. G. Adams, Ross Hackler, B. R. Gibson, B. C. Johnson and A. L. Neumann, *University of Illinois.*

Palatability tests, nitrogen balance and digestion trials and finally a practical feeding test were conducted to determine if dessicated sewage sludge can be used as a satisfactory substitute for a substantial portion of the ordinary protein supplements used in beef cattle rations. This material is available in unlimited quantities and contains approximately 30 percent protein equivalent, much of which is in non-protein nitrogenous form. Six light yearling steers were used to determine the upper levels of intake which are readily consumed. One pound of sewage sludge per day was readily consumed and as much as 1.6 lb. per day were consumed by one steer although this steer's feces were very loose and excessive urination was noted, doubtless due to the high level of total mineral content (approximately 40 percent) of the sludge. Six steers were used in a 2×2 latin square designed nitrogen balance and digestion trial. A conventional growing ration containing soybean oil meal as a protein supplement was compared with a similar ration in which all of the protein supplement was replaced by dessicated sludge. The apparent digestion coefficients of the nitrogen were 73.5 and 64.5 percent respectively, the difference being statistically significant at the 1 percent level. The nitrogen reten-

tion values and biological values of the protein were also significantly lower for the sludge ration. Two lots of 5 steers each were equal-fed limited amounts of rations similar to those mentioned above for 56 days with resulting daily gains of 0.79 and 0.75 lb. respectively. Results of ad libitum feeding of full-fed rations will be presented.

A STUDY OF THE EFFECT OF HIGH-TEMPERATURE DRYING OF HIGH-MOISTURE FIELD SHELLED CORN WHEN FED TO BEEF STEERS. W. W. Albert and A. L. Neumann, *University of Illinois.*

Field-shelling of high-moisture corn with either adapted combines or newly developed row-type picker-shellers is on the increase and is apt to become much more common. The high daily capacity of such machines results in the necessity for drying at rather high temperature in order to permit the storage of each day's harvest. Corn processors are reluctant to buy such corn because the high-temperature drying alters the corn enough to upset their normal processing procedures. Farmers, upon having the selling price of such corn reduced or upon having purchase refused entirely are concerned as to whether the feeding value of such corn is altered. Corn, carrying 30 percent moisture, was harvested and then dried at 180° F. until reduced to 16 percent moisture and stored. Similar corn, more mature stage and carrying 16 percent moisture at harvest time was also shelled and stored but without drying. Two lots of 10 heavy choice steer calves each were equally full-fed rations of corn silage, alfalfa hay, soybean oil meal and shelled corn for 126 days. The average daily gains for the lot receiving regular field dried corn was 2.46 lb. while the lot being fed the high-temperature dried corn gained 2.42 lb. daily. Average costs per 100 lb. gain were $18.09 and $17.98, respectively. Under the conditions of this test, no differences were found which should discourage cattle feeders from harvesting corn by this method.

UTILIZATION OF PHOSPHORUS FROM VARIOUS INORGANIC SOURCES BY LAMBS. C. B. Ammerman, R. M. Forbes and U. S. Garrigus, *University of Illinois.*

Sixteen weanling lambs averaging 60 lb. were used for evaluating dicalcium phosphate, Curacao Island phosphate, soft phosphate with colloidal clay, and defluorinated rock phosphate as a source of phosphorus. A semi-purified basal ration was used which contained about 0.03 percent phosphorus. The inorganic supplements contributed at least three-fourths of the total phosphorus in the ration. The Ca:P ratio was the same in all experimental rations. Lambs were individually fed the basal ration for four weeks, the last 6–7 days being a collection period. The phosphorus supplemented rations were then fed during four consecutive 3-day collection periods. Blood samples were drawn at the beginning of the test, and prior to and just following the supplemental feeding period. Blood serum phosphorus levels, expressed in milligrams percent, fell during depletion from about 10 to 6 and rose for the supplements as listed above by average amounts of 2.4, 2.6, 1.3 and 1.3, respectively (not significantly different). Preliminary analysis of part of the phosphorus balance data indicates significant differences in percent phosphorus retained between phosphorus supplements at about the one percent level.

THE EFFECT OF TALLOW, LECITHIN AND ANTIBIOTICS ON GROWTH AND CARCASS QUALITY OF DRYLOT HOGS. D. M. Baird, *Georgia Experiment Station.*

To determine the effect on rate of gain, feed efficiency, carcass quality and economic feasibility, 5 percent stabilized prime tallow was substituted for an equal amount of grain and fed alone and in combination with aurofac, lecithin and a

fermentation product and compared with a basal ration to fattening hogs in drylots from weaning to 190 lb. All rations were equated for protein and fed freechoice. Nine hogs were used per lot. Manual hardness grades and back fat measurements were made following slaughter and cooling. Back and kidney fat samples were taken for refractive index readings. The rations fed, average daily gain, daily feed consumption and feed per 100 lb. gain were as follows: Lot I, Basal 1.35, 6.26, 462.4; Lot II, Basal + 0.5 percent; Fermentation product 1.59, 6.08, 381.8; Lot III, Basal + 0.5 percent; Aurofac 1.59, 6.22, 391.1; Lot IV, Basal + 5.0 percent fat 1.42, 4.45, 312.5; Lot V, Basal + 4.5 percent fat + 0.5 percent lecithin 1.37, 4.60, 336.1; and Lot VI, Ration V + 0.5 percent Aurofac 1.88, 5.44, 289.5 (LSMD for ADG 5 percent level, .28; 1 percent .44). No differences were apparent in dressing percentage and back fat covering. Refractive index readings showed all fat fed lots to have harder fat than the non-fat fed lots with the back fat harder than the kidney fat. The fat fed pigs apparently deposited a harder back fat due to the higher percent of hard ration fat. Addition of fat decreased daily feed consumption but greatly increased feed efficiency and thus was economically feasible at this level. Lecithin failed to improve performance. The fermentation product used apparently contained antibiotic activity and perhaps other growth promoting factors.

THE ROLE OF CARBOHYDRATES IN UREA UTILIZATION, CELLULOSE DIGESTION AND FATTY ACID FORMATION. I. J. Belasco, *E. I. Du Pont de Nemours and Company.*

Urea utilization and the production and distribution of the volatile fatty acids *in vitro* were found dependent on the amount and type of carbohydrate used as the energy substrate. The extent of urea utilization and fatty acid production were generally greater with starch than with comparable amounts of cellulose. Starch yielded proportionately more valeric, butyric and acetic acid and less propionic acid than cellulose. At high input levels of starch the valeric acid concentration rose sharply with a corresponding decrease in propionic acid concentration. With cellulose as the sole carbohydrate source, the formation of propionic acid appeared to be a straight function of the amount of cellulose digested. In combination with cellulose, dextrose was as effective as comparable amounts of starch in urea nitrogen fixation but yielded higher valeric and butyric acid concentrations. At high input levels, starch and dextrose inhibited cellulose digestion. This was more severe with dextrose and was marked by a sharp increase in the valeric and butyric acid concentrations, compensated by decreases in propionic and acetic acids.

THE EFFECTS OF FEEDING UREA AND STILBESTROL ON RATION DIGESTIBILITY AND ON CALCIUM PHOSPHORUS AND NITROGEN RENTENTION IN LAMBS. M. C. Bell, J. R. Taylor, R. L. Murphree and C. S. Hobbs, *University of Tennessee.*

Twelve wethers fed a fattening type ration were used in a series of digestion and balance trials. The following comparisons were made: (1) urea vs. cottonseed meal, (2) urea and stilbestrol vs. cottonseed meal and stilbestrol, (3) urea vs. urea and stilbestrol, and (4) cottonseed meal vs. cottonseed meal and stilbestrol. This study was divided into six seven-day periods. Standard urinary and fecal collections were taken during the 1st, 2nd, 5th and 6th periods. Stilbestrol was fed at the rate of 4 mg. per head daily during the 2nd, 3rd, 4th and 5th periods. A significantly greater digestibility of crude protein and significantly less digestibility of NFE and ether extract was found from lambs fed rations containing urea as compared with those fed the rations containing cottonseed meal. Urea feeding had no noticeable effect on the retention of calcium, phosphorus or nitrogen. Stilbestrol

feeding had no significant effect on the digestibility of ration nutrients. The feeding of stilbestrol significantly increased the daily nitrogen retention during the first seven days (4.9 vs. 3.9 gm.) but there was no carryover effect after stilbestrol feeding was discontinued. Stilbestrol feeding significantly increased calcium and phosphorus retention during the last seven days (1.3 gm. Ca vs. 0.6 gm. Ca and 1.1 vs. 0.3 gm. P) and there was a significant carryover effect after stilbestrol feeding was stopped. These results show that urea can be used as a protein substitute and that stilbestrol feeding increases the retention of calcium, phosphorus and nitrogen by lambs.

PELLETED RATIONS FOR FATTENING LAMBS. T. Donald Bell, A. B. Erhart and D. Richardson, *Kansas State College.*

Pellets containing field cured alfalfa hay alone and in combination with corn in varying amounts, dehydrated alfalfa hay combined with corn in varying proportions, and dehydrated sorghum fodder and stover combined with sorghum grain and a protein supplement, have been fed experimentally to feeder and creep-fed suckling lambs for the past six years. The results have been compared with those obtained when similar but unpelleted feeds were fed. Lambs fed the pelleted rations containing 65 percent roughage and 35 percent concentrates, have gained faster with more efficient use of their feed than lambs given similar but unpelleted rations. Pelleted rations with a higher proportion of concentrates have occasionally caused digestive disturbances resulting in poor feedlot gains and efficiency of feed use. In contrast, unpelleted rations containing approximately 55 percent roughage and 45 percent concentrates gave better results that those with more roughage in them. Digestion and balance studies with lambs receiving dehydrated alfalfa-corn pellets and those receiving field cured alfalfa hay-corn pellets indicated that the protein and fat of the pelleted rations were more efficiently digested and the fiber less completely digested than in the unpelleted rations. Feed cost per pound of gain was higher when pelleted rations were fed in virtually all of the tests, despite the greater efficiency of feed utilization, because of processing costs of $12 to $15 per ton.

THE USE OF VALERIC ACID, BIOTIN, PARA AMINOBENZOIC ACID AS SUPPLEMENTS TO STEER AND LAMB RATIONS. O. G. Bentley, J. H. Cline, E. W. Klosterman, R. R. Johnson and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Valeric acid, biotin and p-aminobenzoic acid which have previously been shown to have growth factor activity for ruman microorganisms *in vitro* were fed to fattening steers and to wether lambs to evaluate their posible practical value *in vivo*. Steers implanted with stilbestrol fed ground ear corn and cobs, urea, corn gluten meal, minerals vitamins A and D supplemented with the "rumen factors" gained 2.60 lb. per day while those on the basal ration, 2.44 lb. per day. This difference was not statistically significant. The supplemented steers ate 10.6 percent more ground ear corn. Feed efficiency was not improved. The "rumen factors" were also used as a supplement for steers fed a practical type ration. There was no significant effect of the factors on the rate of gain of the steers, although the steers receiving 1.5 lb. of soybean oil meal per day and the "rumen factors" gained 0.09 lb. per day faster than their controls. In metabolism studies with lambs fed a cerelose, starch, wood cellulose, corn oil, urea, corn gluten meal, minerals, and vitamin A-D ration, it was found that the addition of the "rumen factors" significantly increased dry matter intake. There was no effect on the digestibility coefficients for either cellulose, protein or total dry matter. Further

work on the value of these "rumen factors" as supplements to practical rations is needed. It would appear that *in vivo* these "rumen factors" increase the rate of rumen digestion while the percent digestibility of the feed is unaffected.

MIXING FACTORS INFLUENCING FEED ADDITIVE PERFORMANCE. Loren V. Burns, G. D. Miller and R. W. Lewis, *Agri-Tech, Inc., Kansas State College and Burns Associates.*

The increasing use of minute quantities of feed additives in animal rations has sharply increased the requirement for uniform dispersion of ration components. Although the fundamentals of mixing are not well established, recent studies indicate that particle size is a critical factor in attaining adequate dispersion. Investigation of particle size distribution in animal rations and in feed additives indicates that particle size is much more critical than previously assumed. Preliminary consideration of the problem indicates that rations may have to be much finer than currently accepted if adequate dispersion of additives is to be achieved. Performance criteria indicate that particle size control and careful mixing techniques may be necessary to reduce the variability of experimental rations to acceptable limits and to secure optimum performance from commercial rations.

STUDIES IN RUMINANT NUTRITION. I. A PURIFIED DIET FOR DAIRY CATTLE. J. H. Byers, J. R. Staubus, W. O. Nelson, R. E. Brown, C. L. Davis and K. E. Gardner, *University of Illinois.*

Eight Holstein steers weighing approximately 400 lb. have been fed a "purified diet" for more than two months. Fiber is supplied by wood cellulose, soluble carbohydrate by corn starch and sucrose, fat by hydrogenated beef tallow, nitrogen by urea and minerals by a complex mineral mixture. The National Research Council's vitamin recommendations were followed as closely as possible through the use of synthetic vitamins. All steers gained weight during the first four weeks on the diet. Subsequently nearly all steers have lost weight. It is believed the difficulty in obtaining body weight gains is due to low palatability of the ration or some unknown nutritive requirements of ruminants. Abnormal conditions such as blindness, enlarged pasterns and unthriftiness were observed. When four of the eight steers were changed from a 55 percent wood cellulose ration to a 35 percent ration the physical appearance of the animals improved. Two steers died after 6 and 9 weeks on the diet. Digestion and nitrogen-balance trials were run on two steers on each of the 55 and 35 percent wood cellulose rations. Results indicate that decreasing the percentage of wood cellulose (fiber) and increasing the percentage of soluble carbohydrates (corn starch) increased the total dry matter digestibility. The animals on both diets had low crude fiber digestibility coefficients. The animals on the 35 percent wood cellulose ration were in positive nitrogen-balance and those on the 55 percent wood cellulose ration were in negative nitrogen balance. Further studies of fiber-nitrogen relationships are planned.

AN ALL CORN DIET FOR DAIRY COWS. J. H. Byers, Leon Luber, W. O. Nelson, R. E. Brown, C. L. Davis and K. E. Gardner, *University of Illinois.*

Twenty-eight dairy cows were divided into four groups and fed for five months on the following rations: Group I received corn silage as the sole roughage, and ground shelled corn; Group II, corn silage, ground shelled corn supplemented with 3.5 percent urea; Group III, corn silage, alfalfa hay, and ground shelled corn; Group IV (control group), was fed corn silage, alfalfa hay, and 14–15 percent crude protein concentrate. Milk production, body weight, palatability of the rations, and physical appearance of all were studied. Digestion and nitrogen-balance trial on

25 of 28 animals were run. Preliminary data would indicate that cows on a corn diet lose body weight, develop a rough hair coat and an unthrifty appearance. Consumption of ground shelled corn and corn silage is not sufficient to maintain positive nitrogen-balance even though milk production may be maintained. Group II cows lost body weight, developed an unthrifty appearance while maintaining milk production. Data from nitrogen-balance trials proved these animals to be in positive nitrogen balance. Addition of urea to a corn diet decreased palatability but increased digestion coefficients. Group III cows lost weight until corn silage and alfalfa hay were increased, even though they maintained milk production. Group IV behaved as expected. Dry matter digestibility coefficients were as follows: six cows on corn silage and ground shelled corn averaged 60.63 percent; seven cows on corn silage and ground shelled corn with 3.5 percent urea averaged 68.77 percent; seven cows on corn silage, alfalfa hay, and ground shelled corn averaged 67.58 percent; and five cows on corn silage, alfalfa hay, and 14–15 percent crude protein concentrate averaged 64.33 percent. Statistical analyses show that rations II, III and IV are significantly superior to ration I, and that rations II and III are significantly superior to ration IV.

AMINO ACID SUPPLEMENTATION OF DEGOSSYPOLIZED COTTONSEED MEAL FOR SWINE. C. C. Chamberlain and E. R. Lidvall, Jr., *University of Tennessee.*

Cottonseed meal, degossypolized by chemical means, was fed with and without amino acid supplementation, and with and without antibiotic. The 99 pigs used in this experiment received protein supplement and corn free choice on pasture. Pigs receiving CSM as a sole protein source gained at the rate of 1.28 lb. per day using 98 lb. of CSM and 323 lb. of corn per cwt. of gain. When Aurofac 2A was added, the gains were 1.22 lb. per pig per day and feed consumption was 89 lb. supplement and 331 lb. of corn per cwt. gain. When 0.5 percent L-lysine was added to the CSM, the gains increased to 1.36 lb. per animal daily and when antibiotic was added to this the gains were 1.53 lb. daily per animal. Feed consumptions were respectively 46 lb. of supplement and 323 lb. of corn and 46 lb. of supplement and 298 lb. of corn per cwt. gain. When the L-lysine was reduced to 0.2 percent the gains were 1.43 lb. per day, and 1.54 lb. per day when antibiotic was added. The feed consumptions respectively were 61 lb. of CSM and 288 lb. of corn and 48 lb. of supplement and 287 lb. of corn per cwt. gain. When antibiotic was added to CSM supplemented by L-lysine at the 0.5 percent level it reduced corn consumption and at the 0.2 percent level it reduced protein consumption.

USE OF DEGOSSYPOLIZED COTTONSEED MEAL IN GROWING-FATTENING SWINE RATIONS, C. C. Chamberlain and E. R. Lidvall, Jr., *University of Tennessee.*

Cottonseed meal, degossypolized by chemical methods, was used as a sole source of protein, and in combination with other plant and animal proteins in rations for growing-fattening swine. These supplements were fed free choice with corn to 130 pigs on pasture. Average total feed consumption per cwt. gain in lots receiving 67 percent soybean meal and 33 percent meat scrap was 326 lb. compared to 316 lb. in lots receiving 50 percent CSM and 50 percent meat scrap. The latter lots consumed 33 percent less protein per hundredweight of gain, 39 lb. versus 60 lb. When the CSM was raised to 67 percent and the meat scrap reduced to 33 percent, the protein consumption was 67 lb. per cwt. of gain, and 73 lb. when SBOM replaced the meat scrap and corn consumption was 298 lb. and 300 lb., respectively. When CSM was the sole source of protein 80 lb. of protein supplement and 326 lb. of corn were required per hundredweight of gain. Average daily

gains were 1.72 lb. using a protein supplement, 67 percent SBOM, 33 percent meat scrap; 1.52 lb. with 50 percent CSM, 50 percent meat scrap; 1.58 lb. with 67 percent CSM and 33 percent meat scrap; 1.44 lb. with 67 percent CSM, 33 percent SBOM; and 1.25 lb. with CSM. The feeding of degossypolized CSM in this experiment resulted in somewhat slower average daily gains.

CALCIUM AND PHOSPHORUS REQUIREMENT OF GROWING-FINISHING SWINE. H. L. Chapman, Jr., C. Y. Roberts, J. Kastelic, G. C. Ashton, D. V. Catron and P. G. Homeyer, *Iowa State College.*

The dietary level of calcium and phosphorus necessary to assure optimum rate of gain and skeletal development for 100, 150 and 200 lb. pigs was re-evaluated. employing four replications of a partial seven by seven factorial design. Each replication consisted of 25 lots of three pigs each. Dietary levels of calcium and phosphorus ranged from 0.2 through 0.8 and 0.2 through 0.7 percent, respectively. Evaluating criteria were rate of gain, feed efficiency, weight, breaking strength and ash content of femurs, as well as phosphorus, calcium, potassium, sodium and magnesium content of the femur ash. Flame spectrophotometric analysis revealed no significant difference in the calcium, potassium, magnesium or sodium content of the ash. There was no significant change in the phosphorus content of the ash. A multiple regression analysis indicated that 67–76, 76–93 and 75–88 percent of the variability in average daily gain, breaking strength of femurs and femur ash content, respectively, was attributable to variations in the dietary level of calcium and phosphorus. Of the two elements, phosphorus had the greater influence as indicated by these three criteria of response. The dietary level of calcium and phosphorus needed, based on all criteria, to insure optimum rate of gain and skeletal response for swine fed antibiotic-supplemented rations, appears to be 0.8 and 0.6 percent, respectively, for the 100 lb. pig. These levels may be reduced to 0.7 and 0.5 percent for the 200 lb. growing-finishing pig.

EFFECT OF PLANE OF NUTRITION ON THE CAROTENE REQUIREMENTS OF BEEF COWS DURING EARLY LACTATION. D. C. Church, L. S. Pope and Robert MacVicar, *Oklahoma Agricultural Experiment Station.*

In two trials, involving 24 grade Hereford cows each, the effect of adequate and inadequate planes of nutrition on the carotene requirements of beef cows nursing calves was investigated. The cows had grazed native pastures the previous summer and were allotted to two groups approximately five months prior to parturition on the basis of liver vitamin A stores. One group was fed sufficient cottonseed meal, milo, minerals and weathered grass hay to meet all nutrient requirements with the exception of carotene; the other group received approximately one-half the amount of supplement fed the first group. Following parturition, one-half of the cows within each plane of nutrition received 30 mg. carotene daily (one-tenth N.R.C. allowance) and the remainder, 150 mg. (one-half N.R.C.). The experiment terminated when the calves were three months of age. Carotene intakes of 150 mg. were reflected in higher blood vitamin A levels in both trials, but in increased liver stores of the cows in only one trial. No symptoms of vitamin A deficiency were noted in any of the cows. Little effect was observed in liver and blood vitamin A levels of their calves. Unthriftiness, scours, respiratory infections and death loss were noted in calves of all lots except where the cows were adequately fed and received 150 mg. of carotene. It appears that the carotene requirements of beef cows may be lower than the N.R.C. allowance if the cows are properly fed.

DEVELOPMENT OF PHOSPHORUS AVAILABILITY ASSAY TECHNIQUES WITH THE BABY PIG. G. E. Combs, Jr., G. C. Ashton, J. Kastelic, V. C. Speer, M. Emmerson and D. V. Catron, *Iowa State College.*

A series of 5 experiments were conducted to investigate the feasibility of using blood serum alkaline phosphatase, skeletal and soft tissue composition, bone opacity and growth rate of baby pigs as response criteria for evaluating the biological availability of the phosphorus contained in various phosphate supplements. The experimental pigs had an average initial weight and age of 6.2 lb. and 8.1 days, respectively, and were fed a semi-synthetic ration for a 28-day period. Mono- and dicalcium phosphate, bone meal and soft phosphate with colloidal clay were added individually to this ration to supply graded levels of phosphorus at $\log_{10}$ intervals of 0.1505 or 0.301. When growth rate, serum phosphatase activity, rib and femur ash, and the degree of femur X-ray opacity were used as the criteria, the response data met the tests for linear regression of response on phosphorus levels satisfactorily. The ash content of certain soft tissues and the phosphorus content of both skeletal and soft tissues proved unsatisfactory as criteria of response. The precision of the several response criteria as measured by the statistic lambda (slope/standard deviation of an experimental unit) was variable. Approximate average values obtained for lambda were: growth rate 0.15; serum phosphatase activity 0.15; femur ash 0.09; and rib ash 0.13; and femur X-ray opacity 0.07. The criteria of choice depends then upon the degree of precision desired, the funds and the equipment available. Using the same number of animals, the more precise criteria, ash content of femurs and ribs and femur X-ray opacity, are those which require sacrificing the animals.

EFFECTS OF MASSIVE ORAL DOSES OF VITAMIN D UPON THE PHYSIOLOGICAL BEHAVIOR OF RADIOCALCIUM AND PHOSPHORUS IN CATTLE. H. R. Conrad, Sam L. Hansard, J. W. Hibbs and H. Patrick, *Tennessee and Ohio Agricultural Experiment Stations.*

Paired Hereford calves, mature steers and dry dairy cows (Jerseys and Guernseys) were used to study the effect of high levels of vitamin D (5–30 million USP units daily) feeding for short perods upon the absorption, retention and movement of calcium, phosphorus and radiocalcium and radiophosphorus in cattle. Seven and ten day balance studies, daily blood calcium and phosphorus changes, autoradiograms and tissue concentration values indicated that: (1) In both young and mature animals excess vitamin D increased calcium and phosphorus absorption from the intestines. (2) There were increased endogenous losses, however, resulting in little difference in net retention. (3) Plasma calcium and phosphorus levels remained somewhat constant during the five day vitamin D feeding period but gradually increased during the period after vitamin feeding was terminated. Radiocalcium tended to be maintained at a slightly higher level in vitamin D treated animals. (4) High vitamin D feeding appeared to have an earlier and more pronounced effect on plasma phosphorus levels which were observed to increase both during and following the vitamin D feeding period from a prefeeding level of 4–8 mg. percent to 9–12 mg. percent. Autoradiograms of sagital bone sections and tissue concentration values confirmed these observations.

A STUDY OF THE NUTRITIONAL LIMITATIONS OF CORN SILAGE AND GRASS SILAGE FOR BRED SOWS. J. H. Conrad and W. M. Beeson, *Purdue University.*

The results of two experiments indicate that normal healthy litters can be produced when bred sows are fed only corn silage as a source of carbohydrate properly supplemented with proteins, vitamins and minerals. Eighty head of bred

sows were used to study the nutritional limitations of corn and grass silage as a feed for sows during gestation. A completely balanced corn-oats-alfalfa meal type ration served as the basal in both experiments, and the silage was fed free choice. In experiment I, the four treatments used were as follows: Lot I—Basal; Lot 2—Grass silage plus corn and minerals; Lot 3—same as 2 plus protein; Lot 4—Corn silage plus protein, vitamins and minerals. The sows in the respective lots weaned (8 weeks) 69, 52, 67 and 75 percent of the pigs farrowed. In experiment II, the four treatments were as follows: Lot 1—Basal; Lot 2—Corn silage plus protein, vitamins and minerals; Lot 3—Same as Lot 2 plus alfalfa meal; Lot 4—Same as Lot 2 plus fish solubles. The sows in the respective lots farrowed an average of 11.1, 12.5, 13.1 and 13.2 pigs per litter and 73, 69, 72 and 64 percent of the pigs farrowed were weaned (8 weeks). The results of experiment I indicated that ground corn and minerals alone were not a satisfactory supplement for grass silage. One pound of a high quality protein supplement per sow daily in addition to corn and minerals were needed for satisfactory reproductive performance. Experiment II showed that 1.5 lb. of a protein supplement (soybean meal 53 percent, meat and bone scraps 25, alfalfa meal 15, bonemeal 4, salt 2, vitamin mix 1 percent) per sow daily would correct the nutritional limitations of corn silage.

THE EFFECTS OF FEEDING DEMETON (SYSTOX)-TREATED ALFALFA TO DAIRY COWS. P. A. Dahm and N. L. Jacobson, *Iowa State College.*

Three dairy cows were fed Systox (a systemic insecticide with cholinesterase-inhibiting properties)-treated hay, containing an average residue of 41 p.p.m., continuously for 56 days to determine if residue toxins would appear in the milk or would affect the cows adversely. The residue toxins consumed ranged from 0.29 to 0.38 mg. per kg. body wt. per day. Two cows fed untreated alfalfa hay served as controls. The treated hay had no adverse effects on milk production, milk fat percentage, body weight changes, and general health of the animals. No residue toxins, as estimated by cholinesterase inhibition, were detected in the milk. However, the cholinesterase activity in the red blood cells showed a gradual decline when the treated hay was fed.

RELATIONSHIP OF PLASMA CAROTENOIDS AND PLASMA VITAMIN A TO CAROTENE INTAKE FROM ALFALFA IN HOLSTEIN CALVES. K. L. Dolge, J. E. Rousseau, Jr., R. Teichman, H. D. Eaton, G. Beall, H. L. Lucas, Jr. and L. A. Moore, *Storrs (Conn.) Agricultural Experiment Station, North Carolina State College and U.S.D.A.*

Plasma carotenoids and plasma vitamin A values plotted against intake of carotene for 113 Holstein calves, which received fixed or increasing intakes of carotent from alfalfa, indicated that the law of diminishing returns was operative. In an attempt to obtain linear relationships, the plasma values were plotted against log (carotent intake); however, the variances associated with the plasma values increased with increasing log (carotent intake) and plasma carotenoids showed slight positive curvature. In order to minimize differences among the variances, the log (plasma carotenoids) and log (plasma vitamin A) values were fitted on the log-log (carotent intake). This transformation largely eliminated increases in the variances about the plasma values associated with increasing carotent intake and resulted in essentially linear relationships. For plasma carotenoids, this relationship was best expressed as $Y_1 = 0.8 + 2.5898 \times \pm 0.1896$ and for plasma vitamin A, $Y_2 = 0.81 + 1.2330\ X \pm 0.1160$ in which $Y_1 =$ log (plasma carotenoids) $Y_2 =$ log (plasma vitamin A) both in mcg./100 ml. and $X =$ log-log (carotene intake) in mcg./lb. live weight/calf/day. These functions accounted for 75 percent of the

variation about log (plasma carotenoids) and for 64 percent about log (plasma vitamin A). Log (plasma carotenoids) was found to be slightly more responsive to increase in log-log (carotene intake) than log (plasma vitamin A).

PREVENTION OF VITAMIN E DEFICIENCY IN LAMBS BY ORAL ADMINISTRATION OF DIPHENYL-P-PHENYLENEDIAMINE. H. H. Draper and B. Connor Johnson, *University of Illinois.*

Five groups of day-old lambs were fed an artificial milk diet containing, on a dry matter basis, 30 percent "vitamin-free" casein, 36 cerelose and 28 percent "stripped" lard as sources of protein, carbohydrate and fat, respectively. Diphenyl-p-phenylenediamine (DPPD) was administered daily to three groups at levels equivalent to 0.001, 0.025 and 0.10 percent of the dry matter intake. Another lot received the unsupplemented basal diet and a final group was given a supplement of 50 mg. of alpha-tocopherol per lb. body weight once weekly. Clinical manifestations of muscular dystrophy and histological examination of the gastrocnemius muscle were used as criteria of vitamin E adequacy. Lambs subjected to the basal regimen, either alone or supplemented with 0.001 percent DPPD, developed "stiff lamb disease" in 4 to 5 weeks. Those receiving 0.025 percent DPPD exhibited clinical and histological evidence of mild muscular dystrophy after 6 weeks. The animals given 0.10 percent DPPD or alpha-tocopherol remained normal in both respects. These results demonstrate that vitamin E deficiency in newborn lambs fed a tocopherol-deficient diet can be prevented by the oral administration of DPPD. Under the conditions described the minimum level of DPPD necessary for complete protection to an age of 6 weeks is greater than 0.025 percent and not more than 0.10 percent of the dry matter intake.

THE UTILIZATION OF NITROGEN BY LAMBS FROM PURIFIED RATIONS CONTAINING UREA, GELATIN, CASEIN, SOYBEAN PROTEIN, AND BLOOD FIBRIN. W. C. Ellis, G. B. Garner, M. E Muhrer, W. H. Pfander, *University of Missouri.*

Sixty nitrogen balance trials involving 14 lambs were conducted. Eight hundred grams of a purified ration containing Solka-Floc, 40 percent; starch, 27.5; cerelose, 15; lard, 2; minerals, 5; and 10.5 percent a mixture of the nitrogen source, cerelose, and vitamins A and D constituted each animal's daily ration. This ration contained approximately 7 percent crude protein ($N \times 6.25$). During the nitrogen free period lambs were force fed, via ruminal cannula, 800 gm. of the purified ration, with cerelose replacing the nitrogen source. Mean urinary endogenous nitrogen levels of 0.0319 gm. per kilogram body weight and mean metabolic fecal nitrogen levels of 0.00239 gm. per gram of dry matter intake were obtained. True digestibilities (T.D.), daily nitrogen balance (N.B.) in grams, and biological values (B.V.) for the different nitrogen sources were, respectively: urea, 78.5, 0.79, 51.2; gelatin, 83.9, 1.66, 61.2; casein, 84.6, 2.16, 69.2; soybean protein, 85.6, 2.86, 82.0; and blood fibrin, 80.5, 2.79, 81.6. There were no significant differences in the T.D. of different nitrogen sources. There were no significant differences in the N.B.'s and B.V.'s of casein vs. gelatin and soybean protein vs. blood fibrin. The N.B.'s and B.V.'s of soybean protein and fibrin were significantly larger than those for casein and gelatin which were significantly larger than those for urea. These studies demonstrate the superior utilization of "true" protein, as compared to urea, by sheep and suggest tryptophan as one limiting amino acid of the microbial protein formed in the casein and gelatin supplemented sheep.

THE EFFECTS OF PROTEIN SUPPLEMENTS CONTAINING DEHYDRATED ALFALFA MEAL, BREWERS DRIED YEAST OR MOLASSES ON THE DIGESTIBILITY OF HIGH AND LOW PROTEIN PRAIRIE HAY BY CATTLE AND SHEEP. L. B. Embry, L. E. DuBose, G. F. Gastler and O. E. Olson, *South Dakota State College.*

Digestion trials were conducted with steer calves and wether lambs to determine the value of using 0, 10 and 20 percent dehydrated alfalfa meal, 0, 5 and 10 percent brewers dried yeast, and 0, 10 and 20 percent molasses (half cane and half beet) in protein supplements (25 to 35 percent) fed with early-cut and late-cut native prairie hay. Protein levels of the rations with the two kinds of hay were held approximately the same by varying the proportions of hay and supplement. Dehydrated alfalfa meal and molasses had no apparent effect on the digestibility of protein or organic matter by calves or lambs fed either the early or late hay. However, the lambs consistently digested the protein better than did the calves in the alfalfa meal experiment. Brewers dried yeast resulted in no effect on the digestibility of protein by calves or organic matter by calves or lambs. Lambs digested the protein of the rations better than calves only when the supplement contained no brewers yeast. Digestion coefficients for protein were lower for lambs when brewers yeast was included in the supplement but this resulted largely through the performance by two of the six lambs. The results indicate that the three ingredients have small if any effect on ration digestibility by calves and lambs and that quality of hay did not influence their value.

THE AMOUNTS OF SHORT CHAIN ACIDS FORMED DURING RUMEN FERMENTATION. R. S. Emery, C. K. Smith and C. F. Huffman, *Michigan State University.*

The concentration of acetic, propionic, and butyric acids in 3 bovine rumens was determined at various times after feeding either an all hay ration or one consisting largely of concentrates. Two trials were conducted on each ration. The concentration of each acid first increased and then decreased with time after feeding. The values obtained were fitted to turnover curves. Acetic acid disappeared from the rumen at the rate of 3.3 percent per hour and butyric acid at the rate of 2.7 percent per hour. The standard error was 0.3 percent. The disappearance rate of propionic acid on the high concentrate ration appeared to be 4.6 versus 3.2 percent per hour on the hay ration. The rates for conversion of feed to short chain acids ranged from 35 to 84 percent per hour. The millimoles of acetic, propionic, and butyric acids per 100 gm. of rumen liquid which were produced from one pound of total digestible nutrients were, 0.2 to 0.67, 0.02 to 0.26, and 0.04 to 0.21, respectively. These are the 95 percent confidence level ranges for the data from the 4 trials. The average rumen in these trials was estimated to contain 70 kg of liquid. Using these values, it was computed that the cow obtains 3 to 13 percent of its energy from short chain acids.

DIGESTIBILITY OF STEER FATTENING RATIONS AS AFFECTED BY QUALITY OF ROUGHAGE, FAT, CHLORTETRACYCLINE (AUREOMYCIN) AND STILBESTROL. E. S. Erwin, I. A. Dyer and M. E. Ensminger, *The State College of Washington.*

Forty-eight yearling Hereford steers were allotted to a 2^4 factorial experiment in which chlortetracycline (Aureomycin), fat (bleachable fancy tallow) stilbestrol and roughage (alfalfa and wheat straw) were the variables. The forty-eight steers (sixteen groups of three each) were individually fed an all-pelleted ration for 183 days. Ration 1 consisted of 82 percent ground alfalfa, 11 percent concentrate,

7 percent fat, plus chlortetracycline, 5 mg. per lb.; and stilbestrol, .45 mg. per lb. Rations 2, 3, and 4 were the same as 1 except stilbestrol, antibiotic, and stilbestrol and antibiotic, respectively, were omitted. Rations 5–8 contained 50 percent ground alfalfa and 50 percent concentrate with the same level and sequence of chlortetracycline and stilbestrol supplementation. Rations 9–12 contained 82 percent ground wheat straw, 11 percent concentrate and 7 percent fat with the same level and sequence of antibiotic and stilbestrol feeding. Groups 13–16 received 50 percent ground wheat straw and 50 percent concentrates with the same levels and sequence of antibiotic and stilbestrol as in groups 1–4. Digestibilities of dry matter, crude fiber, crude protein and ether extract were determined by the lignin ratio technique. Results indicate that fat significantly reduced the digestibility of dry matter and crude fiber. Chlortetracycline significantly increased the digestibility of ether extract; whereas stilbestrol did not significantly affect the digestibility of either dry matter, crude fiber, crude protein or ether extract. Coefficients of digestibility of dry matter were significantly higher in the alfalfa rations than the straw rations.

EFFECT OF VARIOUS LEVELS AND PROLONGED SUPPLEMENTATION OF CHLORTETRACYCLINE (AUREOMYCIN) UPON ROUGHAGE DIGESTION BY SHEEP. J. L. Evans, R. B. Grainger and C. M. Thompson, *Kentucky Agricultural Experiment Station.*

Twenty wether lambs were allotted into five groups of four wethers each and fed a basal ration composed of 80 percent corncobs and 20 percent concentrate mixture. Lot 1 received the basal ration; Lot 2, basal plus 1 mg. of crystalline chlortetracycline (Aureomycin); Lot 3, basal plus sufficient aureofac 2A to furnish 1 mg. of antibiotic activity per pound of feed; Lot 4, basal plus 2 mg. of antibiotic; Lot 5, basal plus aureofac 2A to furnish 2 mg. of antibiotic activity per pound of feed. Average apparent crude fiber digestion coefficients for Lots 1, 2, 3, 4 and 5 were 76.7, 70.7, 71.1, 65.9 and 64.6 percent, respectively. The differences are statistically significant. Experiment II was a repetition of Experiment I with the following modifications. There were three consecutive 10-day collection periods following a 10-day preliminary period, and the levels of chlortetracycline were increased to 5 and 10 mg. per pound of feed. Period 1—the crude fiber digestion coefficients for Lots 1, 2, 3, 4 and 5 were 73.0, 64.6, 65.8, 61.6 and 57.7 percent, respectively. These data are statistically significant. Period 2—the crude fiber digestion coefficients were 70.7, 66.4, 69.9, 61.1 and 64.1 percent. In Lots 4 and 5 the reduction of crude fiber digestibility by antibiotic was statistically significant. Period 3—the crude fiber digestion coefficients were 72.7, 71.0, 69.2, 66.5 and 71.0 percent, respectively. The differences are not statistically significant. The data indicate eventual adjustment of rumen microorganisms to antibiotic supplementation.

IN VIVO RETICULO-RUMEN VOLUMES OF YOUNG DAIRY CALVES AS AFFECTED BY AGE AND DIET. William P. Flatt, R. G. Warner and C. H. Grippin, *Cornell University.*

A technique for measuring the reticulo-rumen volume *in vivo* was used in following the expansion of the reticulo-rumens of calves on various diets. The amount of water removed from the reticulo-rumen after filling the previously cleaned organ to a level of 1.5 inches above the center of a fistula plug, was used as the criterion of reticulo-rumen volume. Ten male Holstein calves fistulated at 6 days of age were allotted to one of the following treatments: (I) mineralized milk, (II) milk plus hay *ad lib*, (III) milk plus dry calf starter *ad lib*, (IV) milk plus dry calf starter and hay *ad lib* at a 2:3 ratio. Triplicate measurements were made on each calf 0, 2, 4, 8 and 12 weeks after treatment began, and the volumes (liters per 45.4 kg. body weight) were respectively: Group I, 2.1, 3.75, 3.75, 4.4, 5.6;

Group II, 3.8, 6.4, 7.6, 10.05, 11.8; Group III, 3.5, 4.95, 7.9, 10.15, 10.65; Group IV, 3.0, 4.5, 6.3, 8.6, 9.6. A highly significant difference ($P < .01$) between treatments was noted at 8 and 12 weeks, with those calves receiving dry feed having the largest capacity per unit of body weight. While the milk-fed calves showed an increase in reticulo-rumen volume with age, the growth was at approximately the same rate as the body weight. There was a close correlation between the volume of feed consumed during the 14 days just prior to measurement and the reticulo-rumen volume.

A PRELIMINARY REPORT ON THE VALUE OF CORN COBS AND COTTONSEED HULLS FOR GROWING DAIRY HEIFERS. G. F. Fries, C. A. Lassiter, D. M. Seath and J. W. Rust, *University of Kentucky.*

Two feeding trials were conducted in order to compare corn cobs and cottonseed hulls with clover-timothy hay as roughages for dairy heifers. Eighteen heifers were used in the first trial which was conducted for 18 weeks. All roughages were fed at an equal rate. A 17 percent protein concentrate was fed with the hay and Purdue Supplement A was fed with the corn cobs and cottonseed hulls. Concentrates were fed at a rate sufficient to meet the minimum protein requirements. Average daily gains were 0.78, 0.92 and 0.69 lb. for the hay, corn cob, and cottonseed hull rations respectively. These differences were not statistically significant. Apparent digestibility of the rations was determined by the chromic oxide indicator method. Average digestion coefficients for dry matter were 59.7, 50.8, and 38.7 percent, for crude protein were 45.7, 57.2, and 37.7 percent, for crude fiber were 55.7, 54.7, 32.0 percent for the hay, corn cob, and cottonseed hull ration, respectively. These differences except between the hay and corn cob rations for crude fiber were highly significant. Blood studies gave no indication of an iron or copper deficiency from the feeding of the cottonseed hull ration. Twelve heifers were used in a second trial which was conducted for 12 weeks. Roughages were fed ad libitum and concentrates in the same manner as in the first trial. Average daily gains were 0.66, 0.67, and 0.80 lb. for the hay, corn cob, and cottonseed hull rations, respectively.

BIURET AS A SOURCE OF NON-PROTEIN NITROGEN FOR SHEEP. William Gaither, U. S. Garrigus, R. M. Forbes and E. E. Hatfield, *University of Illinois.*

Nitrogen balance studies were conducted to compare biuret with urea as a source of NPN for sheep. A semi-purified basal ration containing 0.33 percent nitrogen was supplemented with biuret and/or urea to provide the test rations which contained approximately 2.0 percent nitrogen. Grade wether lambs weighing initially from 64 to 72 lb. received the basal ration supplemented with approximately 4 percent urea for a period of 19 days. They then received the test rations for 18 days prior to the first collection period. The reversal technique was employed so that all lambs served as their own controls on all rations and at two levels of feeding. These studies indicate that biuret nitrogen is retained by lambs as well as urea nitrogen.

THE EFFECT OF THE PHYSICAL FORM OF HAY UPON HAY CONSUMPTION AND GROWTH OF YOUNG CALVES. K. E. Gardner and W. T. Akers, *University of Illinois.*

Forty-eight heifer and bull calves of the five major dairy breeds received alfalfa hay fed adlibitum in one of four physical forms: long (baled), chopped, ground, or ground and pelleted. Calves received 350 lb. whole milk and calf starter fed ad libitum up to 4 lb. daily. Average daily hay consumption was 1.01,

1.13, 1.36, and 2.28 lb., respectively for the calves receiving long, chopped, ground, and pelleted hays respectively, while daily calf starter intake was in the reverse order 2.27, 2.17, 1.88 and 1.52 lb., respectively. Average daily gains were 1.37, 1.43, 1.34 and 1.54 lb. for the groups as listed. Calculated total digestible nutrients required per pound gain were similar for all groups. Differences in digestion coefficients for nutrients in chopped and pelleted hays were not significant. In a second trial the following year, using a different source of alfalfa hay fed either chopped or pelleted, the calves receiving pelleted hay again showed heavier hay intake than calves getting chopped hay, 1.71 compared to .70 lb. daily. The calves getting pelleted hay again ate less starter, 2.33 compared to 2.62 lb., and they showed slightly heavier gains, 1.57 compared to 1.40 lb. for calves receiving chopped hay.

THE EFFECT OF FEEDING NITROFURANS UPON THE GROWTH OF DAIRY CALVES. K. E. Gardner and W. E. Wittorff, *University of Illinois.*

Furacin (5-nitro-2-furaldehyde semicarbazone, Eaton Lab.) was included in the rations of dairy calves from birth to 16 weeks, first in the milk and later in the calf starter at rates of 0.01, 0.10, and 0.30 percent of the total daily dry matter intake to ascertain the effect upon growth and scouring. Eight bull calves and one heifer which received the 0.01 level gained 1.63 lb. daily and showed a total of six days scoured for all calves. A similar control group, receiving no furacin gained 1.56 lb. daily and had a total of 13 days scoured. Of seven bull calves on the 0.10 level one died at 66 days, one was sacrificed at 86 days showing nervous symptoms, and the rest showed average daily gains of 1.30 lb. The group had a total of 17 days scoured. Three bull calves which received the 0.30 percent level of furacin showed slight or no gains, evidenced nervous symptoms and were sacrificed at 14, 24 and 50 days of age. Histological and toxicological studies were made. Furacin feeding produced no apparent change in the efficiency of nutrient utilization.

UPTAKE, DEPLETION AND ALLEVIATION OF FLUORINE IN BONES OF CATTLE AND SHEEP. J. M. Griffith, C. S. Hobbs, R. P. Moorman, R. P. Gregory, G. M. Merriman, W. H. MacIntire and L. J. Hardin, *University of Tennessee.*

The fluorine content of bones from cows, calves and sheep that were fed various controlled levels of fluorine within each test showed: (1) a direct relationship to the level ingested, (2) a direct relationship to time of ingestion until the bone was saturated, (3) a relationship to the age of the animal, and (4) a relationship to the solubility of the fluorine source. Rib biopsy samples were taken periodically from 32 cows that were continuously fed various levels of fluorine ranging from control (8 p.p.m.) to 100 p.p.m. The fluorine content of the rib samples at the end of 26 months on test showed no significant difference from those taken after 62 or 74 months on test, which indicates there may be different bone saturation level for the different levels of fluorine ingested. Analyses of fetal bones show there is a small amount of fluorine transferred through the placental membranes of all cows. The addition of aluminum sulfate or aluminum chloride to the ration decreased the amount of fluorine stored in the bones 30 to 40 percent for cattle ingesting 0–50 p.p.m. fluorine or for sheep ingesting 0–200 p.p.m. fluorine added to their rations. Cows that grazed on pastures containing high amounts of fluorine showed that there was a rapid uptake of fluorine in the bones, and when these animals were removed periodically to a control pasture the bone fluorine content decreased gradually, but had not dropped to the control level at the end of 2.5 years. Cows ingesting fluorine (50 to 600 p.p.m.) from raw rock phosphate stored less fluorine in the bone than animals receiving the same amount from sodium fluoride.

COMBINATIONS OF SOYBEAN MEAL AND LOW-GOSSYPOL COTTONSEED MEAL AS PROTEIN SUPPLEMENTS FOR WEANLING PIGS. C. E. Haines, L. Gillespie and H. D. Wallace, *Florida Agricultural Experiment Station.*

Seventy-two weanling pigs were divided into nine experimental groups (2 lots of 4 pigs each) and self fed in dry lot fortified corn rations containing solvent soybean meal, degossypolized solvent cottonseed meal, expeller cottonseed meal and combinations thereof. Average daily gains and feed required per pound of gain were respectively: all soybean meal 1.71, 3.23; all expeller cottonseed meal 1.40, 3.66; all degossypolized cottonseed meal 1.60, 3.38; three fourth soybean meal and one fourth expeller cottonseed meal 1.66, 3.31; three fourth soybean meal and one fourth degossypolized cottonseed meal 1.74, 3.31; one half soybean meal and one half expeller cottonseed meal 1.64, 3.50; one half soybean meal and one half degossypolized cottonseed meal 1.79, 3.19; one fourth soybean meal and three fourths expeller cottonseed meal 1.62, 3.59; one fourth soybean meal and three fourths degossypolized cottonseed meal 1.71, 3.31. Half of the pigs in each group were supplemented with penicillin and the other half received a combination of penicillin and erythromycin. Average daily gains and feed requirement per pound gain for these treatments were respectively 1.60, 3.36 and 1.70, 3.41.

THE EFFECT OF ADDED FAT ON THE DIGESTIBILITY OF LAMB RATIONS. W. H. Hale and R. P. King, *Iowa Agricultural Experiment Station.*

Fats with three different melting points were added separately to a standard lamb fattening ration to determine the digestibility of the fat and the effect of fat on the digestibility of the dry matter of the ration. The fats used were corn oil, prime tallow, and hydrogenated animal fat. All fats were added at the 0, 4, 8 and 12 percent level in the ration. The added fat replaced an equal amount of corn in the ration. The 4 percent fat addition of any of the three fats appeared to have little if any effect upon digestibility of the dry matter. The two higher levels markedly reduced dry matter digestibility. When feed and feces were corrected for fat content the corn oil had the most detrimental effect upon digestibility of dry matter other than fat. The apparent digestibilities of the fats when fed at the 12 percent level were tallow 92 percent, corn oil 80 percent, and hydrogenated animal fat 64 percent.

PROPERTIES OF UNIDENTIFIED RUMEN CELLULOLYTIC FACTORS IN CERTAIN PROTEIN HYDROLYSATES AND THEIR INFLUENCE ON LIVEWEIGHT GAINS IN LAMBS. Glen Hall, Edmund Cheng, W. H. Hale and Wise Burroughs, *Iowa Agricultural Experiment Station.*

Partial acid hydrolysis of certain proteins yielded factors which enhanced the activity of rumen microorganisms. The addition of these hydrolysates to washed suspensions of rumen microorganisms resulted in a considerable increase of cellulose digestion over a period of 24 hours incubation. Partial acid hydrolysate of chicken feather meal was shown to be more active than that of gelatin or casein. The factors present in these hydrolysates were stable to heat and were dialyzable. They were not removed from acidified or alkaline solutions by steam distillation. They were soluble in water but not in ether. These factors were apparently not identical to any of the known short chain fatty acids. A lamb feeding experiment was conducted to test the influence of these unidentified factors on the liveweight gains using 6 lambs per group. Neutralized 5 percent solution of feather meal hydrolysate in 3 N HCl was added to the ration at levels of 10, 20 and 40 ml. per lb. of ration. Results of a 60-day individual feeding trial showed that lambs receiving 20 ml. feathermeal hydrolysate per lb. of ration made greater gains than the control lambs receiving no hydrolysate in the ration.

FACTORS AFFECTING THE GROWTH-INHIBITING PROPERTY OF DEHYDRATED ALFALFA MEAL IN THE RATION OF SWINE. L. J. Hanson, D. E. Becker, S. W. Terrill and A. H. Jensen, *University of Illinois.*

Three trials were conducted to study the influence of various levels of dehydrated alfalfa meal in a practical ration for swine and to determine the factors affecting the growth inhibiting property of dehydrated alfalfa meal. Weanling pigs weighing about 40 lb. were used in the tests. In the first two trials dehydrated alfalfa meal replaced corn in a corn-soybean oil meal ration at 15 and 30 percent levels. Alfalfa meal was fed both with and without additions of refined corn oil to yield equal calculated TDN levels. When 15 and 30 percent alfalfa meal was added to the ration fed *ad libitum* a significant depression of rate and efficiency of gains was evident. However, when the pigs were equally fed the depression in rate of gain was not as severe. The addition of corn oil completely overcame the depression produced by the 30 percent alfalfa level when equally fed. However, under *ad libitum* conditions, corn oil did not appreciably improve rate of gain but increased feed efficiency. In a third test 1 percent cholesterol was added to the basal and to the 30 percent alfalfa meal ration both with and without corn oil. The addition of 1 percent cholesterol to a 30 percent alfalfa meal ration in the absence of corn oil improved the rate and efficiency of gain; whereas, in the presence of corn oil cholesterol did not yield any beneficial effect. It appears that a majority of the growth depressing property of alfalfa meal in the ration is due to a lowered TDN content of the ration and to a lowered feed intake of the pigs.

A NITROGEN BALANCE STUDY WITH STEERS USING UREA, BIURET, AND SOYBEAN OIL MEAL AS SOURCES OF NITROGEN. E. E. Hatfield, R. M. Forbes, A. L. Neumann and U. S. Garrigus, *University of Illinois.*

Six steers were used in a 3 x 3 latin square designed study. The test rations were designated as urea, biuret and soybean oil meal rations. The ADC of dry matter, nitrogen, ether extract, crude fiber, nitrogen-free extract, and the nitrogen balance were determined. Data for urea, biuret, and soybean oil meal rations will be reported in order. Dry matter ADC averaged 60.2, 60.1, and 62.4; no significant differences due to treatment, period, or steers. The nitrogen ADC averaged 66.2, 62.0 and 65.0. The treatment variance was significant at the 1 percent level, but the period or steer variance was not significant. The ether extract ADC averaged 36.8, 37.1, and 39.3. The treatment was not significant; there was a significant variation due to period, but no significant variation due to steers. The crude fiber ADC averaged 61.4, 60.8 and 66.1. The treatment effect was highly significant; but the period and steer effect was not significant. The nitrogen balance, expressed as a percent of the absorbed nitrogen, was 48.8, 42.3, and 49.1. The treatment was significant at the 2 percent level; steers were significant at the 5 percent level; periods were not significant. The grams of apparent biuret per day appearing in the urine for each steer in each period were 4.93, 18.18, 5.78. The treatment effect was highly significant. The period effect was significant at the 5 percent level. This indicates that an average of 12.8 gm. of actual biuret appeared per day in the urine of steers on the biuret ration. This may be compared with a total biuret intake of 90 gm. per day. There was no definite evidence of a carry-over effect on the biuret excretion.

THE DIGESTION COEFFICIENTS OF FEEDS CONTAINING VARIOUS RATIOS OF HAY TO GRAIN BY FISTULATED STEERS AND MILKING COWS. E. H. Haynes, R. F. Davis, R. G. Warner and J. K. Loosli, *Cornell University.*

In the course of certain fundamental studies on ruminant digestion an opportunity became available to compare the digestibility of feeds containing widely different hay to grain ratios using 500 lb. fistulated steers, and mature milking

cows. High quality U. S. No. 1 alfalfa light grass mixed hay containing 13.4 percent protein and a 14.5 percent protein grain mixture composed of 70 percent ground corn, 28 percent distillers grains with solubles, 1 percent iodized salt and 1 percent dicalcium phosphate were fed. Rations consisted of (1) 100 percent hay, (2) 75 percent hay, 25 percent grain, (3) 50 percent hay, 50 percent grain, and (4) 35 percent hay, and 65 percent grain. The cows were fed for a 5-week preliminary period prior to a 5-day collection period. The steers were fed a 6-week preliminary period prior to a 5-day collection period. The cows were fed hay *ad libitum* prior to the beginning of the preliminary period. At the beginning of the preliminary period a portion of hay was replaced by an equal weight of grain for rations 2, 3, and 4. The steers were fed a level of hay to equal 80 percent of Morrison's Feeding Standards with grain replacing hay in a similar manner to the cows. The percent T.D.N. for each ration for cows and steers respectively were (1) 53.8, 46.1, (2) 62.0, 52.8, (3) 65.0, 60.9, (4) 67.8, 62.7. There was a highly significant ($P < 0.01$) difference between cows and steers which appeared to be due to the reduction of crude fiber and ether extract digestibility by the steers. Digestibility of all other constituents was essentially the same for each group of animals. The problems of fistulation, age, and production on ration utilization bear further investigation.

THE EFFECT OF CHLORTETRACYCLINE (AUREOMYCIN) AND DIETHYLSTILBESTROL ON GROWTH AND CARCASS MEASUREMENTS OF STEERS. J. F. Hentges, Jr., J. A. Black, C. A. Tucker, II and T. J. Cunha, *Florida Agricultural Experiment Station.*

Three feeding trials were conducted with yearling steers to determine the effect of adding chlortetracycline (Aurofac-2A) and diethylstilbestrol (stilbosol) to fattening rations. In two trials, chlortetracycline was fed at the levels of 0, 10, and 20 mg. per live hundredweight daily. Twenty-one steers in three lots were group-fed in Trial I and 18 steers in three lots were individually-fed in Trial II. The basal rations were ground snapped corn, citrus molasses, cottonseed meal and grass hay. Slightly higher weight gains and more efficient feed utilization favored the antibiotic fed lots; however, none of the differences between criteria measured (weight gains, feed efficiency, skeletal measurements, hemoglobin levels, carcass grades, dressing percentages and endocrine gland weights) were statistically significant. In Trial III, 4 lots of yearling steers were full fed a fattening ration of corn, citrus pulp, citrus molasses and alfalfa hay. The treatments were as follows: Lot I, control; Lot II, 10 mg. diethylstilbestrol (stilbosol) daily; Lot III, 10 mg. chlortetracycline (Aurofac-2A) per cwt. daily; and Lot IV, a combination of treatments II and III. Criteria studied were weight gains, feed efficiency, carcass grades, dressing percentages and endocrine gland weights. Average daily gains and feed efficiency during the first 35 days favored Lot IV as follows: Lot I (3.1, 658.77), Lot II (4.3, 513.0), Lot III (3.5, 595.30) and Lot IV (4.3, 490.93). After 10 weeks, the data favored Lot II as follows: Lot I (3.0, 728.23), Lot II (3.7, 662.28), Lot III (3.1, 724.77), and Lot IV (3.5, 670.03).

UTILIZATION OF THE NITROGEN IN SOME AMMONIATED FEEDS BY RUMEN MICROORGANISMS. Truman V. Hershberger, Paul Engle, Orville G. Bentley and A. L. Moxon, *Ohio Agricultural Experiment Station.*

In an otherwise adequate medium, the rate of growth of rumen microorganisms, as determined by the rate of protein synthesis and/or cellulose digestion, is directly proportional to the potentially available ammonia nitrogen. The availability of the nitrogen in several ammoniated feeds for ruman bacterial growth was determined by adding appropriate amounts of the feeds to *in vitro* rumen fermentations. The

availability of the nitrogen from ammoniated molasses, 15 percent protein equivalent, ammoniated invert molasses, 33 percent protein equivalent, ammoniated corn cobs, 14 percent protein equivalent, and ammoniated furfural residue, 29 percent protein equivalent was compared with the availability of urea nitrogen. The availability of the nitrogen in the ammoniated products, as determined by bacterial protein synthesis and/or cellulose digestion, was observed to be related to the free ammonia nitrogen content. The remaining nitrogen appeared to be unavailable to the rumen microorganisms. Digestibility trials were carried out with sheep to determine the availability of the nitrogen in ammoniated invert molasses for rumen microorganisms. The results showed that less than one-third of the nitrogen in ammoniated invert molasses was available to the animal.

PERFORMANCE OF DAIRY CALVES RAISED ON HIGH ROUGHAGE PELLETS. J. W. Hibbs, H. R. Conrad and J. H. Vandersall, *Ohio Agricultural Experiment Station.*

Research on factors involved in the development of early mature type rumen function has resulted in a high roughage calf feeding system in which cost is reduced through early dependence on rumen digestive and synthetic processes and the use of simple grain mixtures with large amounts of good quality roughage. Rumen inoculations are employed to provide an early reliable source of rumen microorganisms. In an effort to overcome the selective eating experienced when loose hay and grain were fed separately and also to simplify the adjustment of hay to grain ratio, a basal ration consisting of 2 parts coarsely ground alfalfa hay and 1 part a simple grain mixture (corn, soybean oil meal and salt) was mixed and pelleted (one fourth inch diameter). The basal pellets contained approximately 15 percent crude protein. Variations from the basal ration made in different batches of pellets included the addition of sources of B-complex vitamins, minerals, and molasses. To date 70 Jersey and Holstein calves have been raised on high roughage pellets to either 12 or 16 wk. of age with limited milk to 7 wk. Average growth rate has exceeded the Ragsdale standard by approximately 24 percent and feed consumption has been greater, especially in the early weeks, than was obtained when loose hay and grain was fed. Evidence of efficient feed utilization was obtained by calculated TDN per lb. gain, digestibility of cellulose *in vivo* and *in vitro,* protein digestibility and rumen volatile fatty acid production.

PREWEANING PERFORMANCE OF A HERD OF HYSTERECTOMY-FARROWED SWINE REARED WITHOUT COLOSTRUM. E. G. Hill, D. C. England and G. A. Young, *The Hormel Institute.*

The performance to 56 days of 543 Chester White swine farrowed by hysterectomy and reared without access to colostrum or serum fractions was studied. The data were collected through two generations and grouped chronologically as follows: (1) The first period, when first generation baby pigs were started in multiple brooder units; (2) the second period, when first generation pigs were started individually in isolation units; (3) the third period, composed of second generation pigs started in isolation units. Average 56 day weights were 22.8 lb. in period one, 26.7 lb. in period two, and 33.5 lb. in period three. Mortalities from all causes were 65.2 percent for period one, 8.3 percent for period two, and 22 percent for period three. A breakdown of mortality losses in the starting units showed a mortality of 51.3 percent of pigs started in multiple brooders, but only 6 to 7 percent mortality of pigs started in the individual isolation units, showing the advantage of housing the baby pigs in individual units for the first week. A study of mortality rates showed that livability increased when the hysterectomy was performed at 5 or less days prepartum.

DIGESTIBILITY AND NITROGEN BALANCE IN YOUNG DAIRY CALVES AS AFFECTED BY ANTIBIOTICS AND AGE. D. E. Hogue, R. G. Warner, J. K. Loosli and C. H. Grippin, *Cornell University.*

The effects of two antibiotics, chlortetracycline and bacitracin, and the effects of advancing age on the digestion coefficients obtained with young dairy calves were studied using eleven Holstein bull calves; four controls, four supplemented with chlortetracycline and three with bacitracin. Both antibiotics were fed at the rate of 40 mg. per 100 lb. body wt. per day. Total collections of both urine and feces for 6 days following preliminary periods of 7 to 10 days were made when the calves were 7 and 16 weeks old. Milk was removed from the diet at 4 weeks and a commercial calf starter and birdsfoot trefoil hay were fed throughout the experiment. The hay to grain ratio was maintained at 2:3 during both trials. The level of calculated TDN intake was limited to approximately 110 percent of Morrison's minimum standard. Protein consumption was considerably above recommended amounts. No statistically significant differences were observed in the digestion of dry matter, ether extract, nitrogen free extract or crude fiber. Chlortetracycline increased the apparent digestion of protein and the nitrogen balance over the control calves ($P < 0.05$). At 16 weeks the calves digested more protein ($P < 0.10$) and indicated a greater nitrogen balance ($P < 0.05$) than at 7 weeks. Dry matter, crude fiber, apparent protein digestion and nitrogen balance (percent of dietary nitrogen retained) for the different groups were, respectively: control, 71.6, 48.4, 73.3, 27.3; chlortetracycline 72.8, 46.8, 76.9, 35.7; bacitracin 71.8, 47.0, 75.2, 30.8; 7 weeks, 71.4, 47.2, 74.0, 28.4; 16 weeks 72.8, 47.6, 76.2, 34.1.

MINERAL REQUIREMENTS FOR CELLULOLYTIC RUMEN MICROORGANISMS. Farris Hubbert, Jr., Glen Hall, R. K. Anderson, Edmund Cheng and Wise Burroughs, *Iowa Agricultural Experiment Station.*

Mineral requirements of bovine rumen microorganisms for maximum cellulose digestion *in vitro* have been investigated by using a washed suspension technique. It was found that removal of each of the following minerals individually from the media resulted in reduced cellulose digestion: sodium, potassium, phosphorus, magnesium, manganese, iron and sulfur. High levels of copper, zinc and cobalt were inhibitory to cellulose digestion. Inorganic nitrogen or urea was required. The interrelationships of various minerals were studied. The results indicate that rumen microorganisms can tolerate a wide range of concentrations of certain mineral elements. Under the conditions of these experiments it was found that potassium chloride can replace sodium chloride to a large extent and maintain near maximum cellulose digestion. Experimental results indicate that the ratio of one to one of potassium chloride to sodium chloride will support maximum cellulose digestion.

COMPARISON OF SOURCES OF CARBOHYDRATES FOR THE BABY PIG. D. B. Hudman, V. C. Speer, G. C. Ashton and D. V. Catron, *Iowa State College.*

Four experiments, involving 665 pigs, were conducted to evaluate carbohydrate sources and levels for baby pigs. Gains and feed efficiencies increased significantly (P .05) from 1–3 weeks as dried skimmilk levels were increased in the diet from 0–20–40 percent; 2.0, 3.05; 2.7, 2.46; and 4.2, 1.68 lb., respectively. Three levels of sugar (15–25–35 percent) in 3 forms (all cane, half cane–half corn, and all corn) in combination with the three levels of dried skimmilk had no significant effects on gains or feed efficiencies. The second experiment was designed to determine which fraction of dried skimmilk (protein or carbohydrate) caused the improvement in performance. Casein and lactose were fed individually and in combination at the level equivalent to that found in the 40 percent dried

skimmilk diet. Average 1 to 5 week gains were: 40 percent Dried Skimmilk 18.6; Casein 14.5; Lactose 10.0; and Casein + Lactose 17.8 lb. To determine the carbohydrate of choice for baby pigs, different sources of carbohydrates were compared in semi-purified diets. Average 1 to 5 week gains and feed efficiencies were: Lactose 10.6, 2.16; 42 DE Corn Syrup Solids 8.8, 2.34; Sucrose 8.6, 2.40; Yellow Corn 8.5, 2.26; Dextrose 8.3, 2.54; 24 DE Corn Syrup Solids 7.8, 2.74; Corn Starch 6.9, 2.62; Oat Groats 6.9, 2.18; Cornflakes 5.5, 3.13; Pre-gelatinized Starch 5.1, 2.81; 10 DE Corn Product 3.8, 3.41 lb. To determine the effect of age on starch utilization, baby pigs were weaned at 3, 6, 9, 12, 15 and 18 days of age and fed a diet in which starch was the sole carbohydrate source. Average 5 week weights for the different weaning times were: 16.0; 18.8; 18.6; 20.2; 17.6; and 19.0 lb., respectively.

STUDIES OF AMMONIATED HYDROL (CORN MOLASSES) IN BEEF CATTLE RATIONS. A. C. Hughes, F. H. Baker, D. Richardson, G. K. L. Underbjerg and R. F. Cox, *Kansas State College.*

Ammoniated hydrol has been studied as a protein substitute for wintering beef cattle in the following experiments: a 140-day feedlot trial using 20 Hereford heifer calves and three digestion trials using nine yearling Hereford steers. In the feedlot the basal ration (Lot 1) was soybean meal, 1 lb.; milo grain, 2 lb.; and sorghum silage ad libitum. In the ration of Lot 2, one-half of the soybean meal was replaced by an equal amount of nitrogen and T.D.N. from ammoniated hydrol (12 percent crude protein equivalent). The silage consumed per heifer daily was 29.5 and 27.0 lb. for Lots 1 and 2, respectively. The average daily gains of the heifers were 1.55 and 1.35 lb., respectively for Lots 1 and 2. A basal ration of soybean meal, 1 lb.; corn, 1 lb.; hydrol, 2.8 lb., and sorghum silage, 36 lb. was used in the digestion experiment. Substitutions of ammoniated hydrol for 50 percent and for 100 percent of the nitrogen and T.D.N. of the soybean meal were made in the experimental rations. The design of the experiment was a series of three Latin squares. Differences in digestion coefficients of crude protein, nitrogen free extract, ether extract, and crude fiber for the three rations were not statistically significant. Blood ammonia levels determined during the study were higher for the animals fed ammoniated hydrol.

THE EFFECT OF ANTIBIOTIC FEEDING LEVEL AND OF LENGTH OF SUPPLEMENTATION PERIOD ON THE RESPONSES OF DAIRY CALVES TO STREPTOMYCIN AND CHLORTETRACYCLINE (AUREOMYCIN). N. L. Jacobson, L. D. McGilliard and R. S. Allen, *Iowa State College.*

Forty Holstein calves were allotted at 4 days of age to a modified factorial experiment designed to study the effects of level of antibiotic feeding (20 and 50 mg. per lb. milk replacement and 10 and 20 mg. per lb. starter) and of length of supplementation period (in milk replacement only, 7 wk. vs. in milk replacement and in starter, 12 wk.). The high level of antibiotic feeding promoted more rapid weight gains than the low level. Feeding antibiotic to 12 wk. resulted in greater weight gains to 12, 16 and 20 wk. than feeding antibiotic for 7 wk. only. The mean weight gains to 4, 8, 12, 16 and 20 wk. for calves fed the high level of antibiotic for 12 wk. were 15, 53, 99, 127 and 183 lb., respectively, as compared to 8, 38, 73, 117 and 164 lb. for calves fed the low level for 7 wk. and 8, 41, 80, 125 and 164 lb. for the controls. When values for both levels and both lengths of supplementation were combined, the gains to 4, 8, 12, 16 and 20 wk. for calves fed streptomycin were 11, 47, 84, 122 and 167 lb. and for those fed chlortetracycline were 11, 45, 88, 123, and 178 lb. No differences among groups in incidence of diarrhea were observed.

EFFECT OF ADDITION OF INEDIBLE TALLOW TO A CALF STARTER FED TO HOLSTEIN CALVES. D. Johnson, Jr., K. L. Dolge, J. E. Rousseau, Jr., R. Teichman, H. D. Eaton, G. Beall and L. A. Moore, *Storrs, (Conn.) Agricultural Experiment Station and U.S.D.A.*

Twenty-four male Holstein calves were fed limited whole milk, a maximum of 4 lb. per day of calf starter containing 0.0, 2.5, 5.0 or 10.0 percent inedible stabilized tallow and *ad lib.* alfalfa pellets to 92 days of age. Those calves fed starters containing tallow consumed more calculated total digestible nutrients which resulted in 5 to 6 percent greater increases in growth. The lb. of dry matter required per lb. of live weight increase was less in those calves fed starters containing tallow, while total digestible nutrient utilization was not appreciably affected. Based on blood plasma values during the above feeding period and during a subsequent vitamin A depletion period carotene and tocopherol utilization was unaffected by the inclusion of tallow in the starter. Digestibility and mineral balance studies with 8 of the above calves and with 4 lambs indicated that when tallow was fed, there was in the case of the calves a decrease in the apparent digestibility of dry matter, organic matter, crude protein and nitrogen-free extract; while ether extract was increased for both species. Fecal calcium increased with the inclusion of tallow in the ration of calves.

THE EFFECT OF VARIOUS LEVELS OF CHLORTETRACYCLINE FED TO RUMINANTS MAINTAINED UNDER COMMERCIAL FEED-LOT CONDITIONS. W. P. Johnson, R. F. Elliott, and L. Shor, *Lederle Laboratories Division, American Cyanamid Company.*

Studies were conducted with 798, recently shipped, southwestern, 61-lb. lambs to determine the effect of chlortetracycline fed under feed-lot conditions. Lambs were divided randomly into 8 equal lots assigned to 4 feeding groups. The basal ration, an average feed-lot ration, was fed to Group 1. Group 2 received basal plus chlortetracycline at 25 mg. per lb. of feed for 21 days, followed by 10 mg. per lb. of feed continuously. Group 3 received basal plus chlortetracycline at 10 mg. per lb. of feed continuously. Group 4 received basal plus 25 mg. chlortetracycline per lb. of feed for 21 days. The feeding period for all groups was 48 days. The results indicate that, under the conditions of this trial, chlortetracycline fed continuously (Groups 2 and 3) resulted in optimum effective daily gains and feed efficiency due to control of mortality. Mortality, when it occurred, was primarily caused by enterotoxemia. The effect of chlortetracycline was considered entirely prophylactic. In a preliminary trial similarly conducted with forty-nine, 700-lb. feeder steers, levels of 3.75, 25, 50, and 100 mg. chlortetracycline per lb. of feed were applied to a full-feeding program, the 3.7-mg. level for the entire feeding period of 124 days, and the three high levels for the initial 21 days. No untoward effects were noted in any of the groups.

COMPARATIVE VALUE OF FEATHER MEAL AND SOYBEAN MEAL AS A PROTEIN SUPPLEMENT FOR FATTENING LAMBS. R. M. Jordan and P. S. Jordan, *University of Minnesota.*

Three lots of 10 native feeder lambs were fed to study the relative value of feather meal as a source of protein for ruminants. The basal ration fed all 3 lots consisted of a full feed of shelled corn, low quality brome hay, salt, and a mixture of lime-stone and trace mineral salts. To this basal ration the following protein supplements were added: Lot 1 received .3 lb. per lamb daily of a supplement consisting of 200 lb. ground corn and 100 lb. of soybean meal. Lot 2 received .4 lb. per lamb daily of a supplement containing 200 lb. ground corn,

100 lb. ground feathers and 100 lb. soybean meal. Lot 3 received .5 lb. per lamb daily of a supplement consisting of 200 lb. ground corn, and 300 lb. of soybean meal. The lambs in Lot 1 received approximately one-third as much protein as fed Lots 2 or 3. The feather meal did not adversely affect the palatability of the ration. Lambs in Lot 2 ate slightly more grain and hay than the lambs in either Lot 1 or 3. Average daily gains per lamb were: .38 lb., .47 lb. and .46 lb. in Lots 1, 2 and 3, respectively.

METHODS USED IN EVALUATING LEVELS OF CONCENTRATE AND ROUGHAGE INTAKE FOR FATTENING STEERS. T. B. Keith, *Idaho Agricultural Experiment Station.*

A technic has been devised to study the most efficient levels of concentrate and roughages to feed fattening steers for optimum results. Since it is difficult to control the intakes of definite ratios of concentrate to roughage by the group-feeding method, it was necessary to resort to an individual feeding program. The failure to control the intake of definite ratios in the past has been the direct cause of inaccurate information on this subject. Also, if group-feeding methods were used, it would require more time and equipment than is available in the average experiment station to arrive at any accurate results. The objectives were: (1) To determine the ratio of concentrate to roughage that would give optimum results; (2) to determine the protein needs for each level of concentrate and roughage; (3) to determine the method of feeding the ratios of concentrate and roughage studied for optimum results. Sixty to 80 steers were fed in individual stalls using a system of hidden replication. This system of investigation makes it possible to get information on the relative value of each ratio of concentrate to roughage, the protein needs of steers fed each ratio, and the rate and economy of gains of steers fed each ratio by a graduated method of concentrate intake and by a constant concentrate intake. Results have been obtained on six ratios of concentrate and roughage, two levels of protein, and two methods of feeding.

A COMPARISON OF A CALCIUM FORMATE COMPOUND, SODIUM METABISULFITE AND MOLASSES AS ADDITIVES TO ALFALFA SILAGE FOR DAIRY CATTLE. K. A. Kendall, K. E. Gardner, R. W. Hemken, J. R. Staubus, G. D. Rolleri and J. H. Byers, *University of Illinois.*

First cutting Alfalfa cut in the early bloom to nearly full bloom stage, containing 25 to 30 percent dry matter (D.M.), was ensiled in 4 silos (1, 2, 3, 4) with additives, on the per ton bases, as follows: (1) none; (2) sodium metabisulfite, 8.3 lb.; (3) Calcium formate compound, 5.7 lb.; and (4) corn molasses, 70 lb. Protein levels in the Alfalfa (D. M. basis) in percent as retained in the silage by treatments were (1) 86.5, (2) 88.7, (3) 92.6 and (4) 93.2. Consistently higher carotene values in the silages were associated with treatments 1 and 4. Silage lots 1, 2, 3, and 4 were fed to 24 milking cows for approximately 18 weeks with 6 cows being fed throughout the period from a single lot. Plasma carotene and vitamin A values were lowest in group 3. Daily silage intakes (ad lib.) for lots 1, 2, 3, and 4 were 44.5, 39.2, 37.2 and 49.9 lb. respectively, whereas daily F.C.M. levels were 23.4, 20.7, 21.5 and 24.5 lb. respectively. In the same order all groups of cows showed average weight differences per cow of —30, —9, —22 and —11 lb. between average 3-day beginning and final weights. Milk carotene and vitamin A values were lower in the cows fed silage from lot 3. In another study in which second cutting Alfalfa was ensiled with calcium formate (A), calcium formate compound (B), sodium metabisulfite (C) or molasses (D) carotene values were lowest in the A and B treated silages.

FACTORS AFFECTING THE DIGESTIBILITY OF FLAX PLANT FEED IN VITRO AND IN VIVO. O. E. Kolari and L. E. Hanson, *University of Minnesota.*

A series of several hundred experiments were conducted with the miniature artificial rumen to determine the effects of varying energy and/or nitrogen levels and minerals on fiber digestion of flax plant feed. On the basis of these results, 12 long time digestion experiments with sheep were completed. Nine wethers averaging 78 lb. were divided into 3 lots of 3 sheep each on the basis of equal weight per lot. Each of the lots was fed 4 different rations, each ration being fed for a total of 4 weeks. Each sheep was fitted with a harness and fecal collection bag so that he could be kept on the floor of the pen. The basal ration consisted of flax plant feed, minerals and vitamins fed in pelleted form. Test ingredients included corn grain, soybean oil meal, molasses and alfalfa, singly and in various combination. Pelleted timothy hay was fed to one lot as a negative control. At the termination of the experiment, the sheep weighed 111.3 lb., to yield an average daily gain of 0.27 lb. per day. The major results of the experiments will be discussed.

THE EFFECT OF CHLORTETRACYCLINE (AUREOMYCIN) FEEDING ON *IN VITRO* CELLULOSE DIGESTION BY RUMEN MICROORGANISMS. M. R. Lambert and N. L. Jacobson. *Iowa State College.*

The effect of Chlortetracycline (Aureomycin) feeding on the ability of rumen microorganisms to digest cellulose was studied, employing the artificial rumen technique. Six collections of rumen liquid were made (at weekly intervals) from each of 16 lactating cows, 8 of which had received approximately 240 mg. of chlortetracycline per cow daily from an early age. After the initial three collections of rumen liquid from the antibiotic-fed cows, the antibiotic was removed from the diet. Feed particles were removed from the rumen samples by slow centrifugation. The liquid then was centrifuged at 2,000 r.p.m. for 20 minutes. The liquid portion was poured off and aliquots of the remaining cells were transferred to artificial rumen tubes containing mineral media and cellulose substrate. During the first three collection periods microorganisms from control cows (no antibiotic) digested 40 percent of the purified cellulose substrate (Solka-Floc) as compared to 31 percent for inocula from cows receiving the antibiotic. When alfalfa hay was used as the substrate, cellulose digestion was 58 percent for the controls and 42 percent for microorganisms from cows receiving the antibiotic. During the three subsequent collection periods, when aureomycin was removed from the diet of the treated cows, cellulose digestion was 45 percent for controls and 47 percent for animals formerly fed aureomycin when Solka-Floc was used as the substrate and 61 percent and 62 percent, respectively, when alfalfa hay was used. Eight calves also were used to study the effect of chlortetracycline on cellulose digestion. Trends were somewhat similar to those observed for the cows but the data were more variable.

THE EFFECT OF VARIOUS SUPPLEMENTS ON THE UTILIZATION OF A LOW QUALITY TIMOTHY HAY FOR DAIRY STEERS. C. A. Lassiter, C. L. Davis, L. D. Brown, M. Cole and G. F. Fries, *University of Kentucky.*

Four yearling dairy steers were used in a once replicated standard digestion trial to study the effect of corn and soybean oil meal as supplements on the digestibility of a low-quality timothy hay. A ten-day preliminary and a seven-day collection period were used. A 4.4 percent crude protein timothy hay (10.2 lb. per day) supplemented with salt, bone meal, and vitamins A and D was used as a basal ration. The basal ration was supplemented with either 2.6 lb. of corn,

2.6 lb. of soybean oil meal or a combination of 1.3 lb. corn and 1.3 lb. soybean oil meal. Corn significantly increased the digestibility of crude protein and significantly decreased the digestibility of crude fiber. Soybean oil meal significantly increased the digestibility of dry matter and crude protein. The combination significantly increased the digestibility of crude protein and significantly decreased the digestibility of crude fiber. Average coefficients of digestibility of dry matter, crude protein, and crude fiber, were 62.9, 34.8, and 63.9 percent, respectively, for the basal ration; 63.9, 42.1, and 57.9 percent respectively, for the basal ration plus corn; 67.3, 76.6, and 62.1 percent, respectively for the basal ration plus soybean oil meal; 61.6, 62.1, and 55.6 percent, respectively for the basal ration plus corn and soybean oil meal. These data indicate that the principal deficiency of the basal ration was protein.

ENZYME SUPPLEMENTATION OF BABY PIG DIETS. C. J. Lewis, D. V. Catron, V. C. Speer and G. C. Ashton, *Iowa Agricultural Experiment Station.*

In the course of studying the qualitative protein and carbohydrate requirements of early weaned baby pigs at this station, it was discovered that baby pigs may not have fully developed proteolytic and amylolytic enzyme systems. Fractionation of dried skimmilk rations, which gave satisfactory performance, revealed that both the protein fraction and the carbohydrate fraction of the skimmilk contributed to its superior performance over soybean protein-corn starch diets. Five experiments, involving 358 baby pigs, have been conducted to determine the value of dietary supplementation with proteolytic and amylolytic enzymes using soybean protein-corn starch, casein-corn starch, soybean protein-lactose and casein-lactose basal diets. Supplementation with proteolytic enzymes increased gains from 0 to 29 percent and improved feed efficiency from 0 to 23 percent, depending upon the enzyme used, with soybean protein and casein basal diets. Proteolytic enzyme supplementation of soybean protein-lactose diets fed to older pigs (initial weight 28 lb.) failed to significantly increase daily gains. This supports previous observations and experience which showed that fortified corn-soybean rations produced satisfactory performance in pigs above 25 lb. This also indicated an enzyme insufficiency in the baby pig rations rather than a protein quality deficiency in the fortified soybean protein rations. A special low molecular weight (50,000) soybean protein used in baby pig rations failed to support the growth rate produced by standardized assay soybean protein (200,000 M.W.). Digestibility studies are in progress.

FACTORS AFFECTING THE BEHAVIOR OF PARAKERATOSIS IN SWINE. Paul K. Lewis, Jr., W. G. Hoekstra, R. H. Grummer and P. H. Phillips, *University of Wisconsin.*

Seventy-nine weanling crossbred pigs were allotted into 10 groups and fed a basal ration consisting of 84.5 percent corn, 11 percent soybean meal, 3 percent meat scraps, 1 percent limestone and 0.5 percent salt. By calculation this ration contained 15 percent protein, 0.68 percent calcium and 0.41 percent phosphorus. The addition of antibiotics, monosodium phosphate or brewer's yeast and dried skimmilk to various basal rations did not significantly increase the average daily gains, but the severity of the skin condition did significantly decrease on the monosodium phosphate ration. Three high calcium rations (1.29 percent calcium) containing supplemental bone meal, limestone or dicalcium phosphate caused significant decreases in average daily gains (from 0.37 lb. per pig per day on the basal ration to 0.08 lb. per pig per day on the high calcium), and hastened the onset of parakeratosis. The addition of 50 p.p.m. of zinc to the

basal or high calcium ration significantly increased average daily gains to 0.73 and 0.89 lb. per pig per day, respectively and significantly decreased the severity of the skin condition. This level of zinc did not completely prevent the appearance of parakeratosis. After 16 weeks on the above rations, the pigs receiving zinc had significantly more zinc in their plasma, but not in erythrocytes, than those pigs that did not receive supplemental zinc. At the end of 12 weeks, 7 of the above lots were reallotted into 5 groups to ascertain the effect of zinc treatment on parakeratosis. At the end of 7 more weeks, the addition of 100 and 500 p.p.m. of zinc to the high calcium ration or the injection of 1 mg. and 2 mg. of zinc per lb. of body weight per day for 10 days significantly increased average daily gains (from 0.09 lb. per pig per day with no treatment to 1.15–1.33 lb. per pig per day on zinc treatments) and nearly alleviated the skin condition.

EFFECT OF PELLETING ON THE DIGESTIBILITY OF LAMB DIETS. Ivan L. Lindahl and R. E. Davis, *Animal and Poultry Husbandry Research Branch, A.R.S., U.S.D.A.*

The effect of pelleting on the composition of 7 diets and on the digestibility of the nutrients by lambs was determined. Pelleting usually reduced the moisture content of feed mixtures even when steam or water was used in the process, and also tended to increase the ether extract and decrease the crude fiber. Feeder lambs were used in reversal trials to compare the digestibility of the pelleted and unpelleted diets. There was a trend toward higher digestibility of the ether extract (significant in 3 of the trials) and lower digestibility of the crude fiber (significant in 2 trials). When the total digestible nutrients were calculated for the diets, using the average digestibility coefficients and the chemical analysis (air dry basis) of the diets, only slight if any differences were noted between the pelleted and unpelleted feeds. The diets studied with the TDN values for the pelleted and unpelleted forms, respectively were: Alfalfa meal, 60.40 and 58.26; Lespedeza sericea hay, 40.83 and 40.81; 75 alfalfa hay, 20 corn and 5 percent molasses, 1st trial, 57.64 and 57.21, 2nd trial 55.12 and 55.81; 70 alfalfa hay, 25 barley and 5 percent molasses, 55.37 and 54.00; 55 alfalfa hay, 40 barley and 5 percent molasses, 59.14 and 59.08; and 40 alfalfa hay, 55 barley and 5 percent molasses, 64.42 and 63.09.

MINERAL INTERRELATIONSHIPS IN PARAKERATOSIS OF SWINE. R. W. Luecke, J. A. Hoefer and F. Thorp, Jr., *Michigan State University.*

In an experiment designed to study the effects of Ca and Zn on the incidence of parakeratosis 40 weanling pigs averaging 28 lb. were divided into 4 lots. The basal ration fed was composed of a mixture of natural feed ingredients. The Ca and Zn contents of the 4 experimental lots were as follows: lot 1, 1.4 percent Ca and 31 p.p.m. Zn; lot 2, 1.4 percent Ca and 53 p.p.m. Zn; lot 3, 0.9 percent Ca and 29 p.p.m. Zn; and lot 4, 0.9 percent Ca and 53 p.p.m. Zn. At the end of the eighth week the incidence of parakeratosis in the 4 lots was as follows: lot 1, 10; lot 2, 1; lot 3, 3; and lot 4, 0. The average daily gain for each of the 4 lots at the end of the eighth week were as follows (in lb.): lot 1, 0.54; lot 2, 1.06; lot 3, 0.91; and lot 4, 1.25. The results indicate that a high Ca level in the ration is at least one of the predisposing factors in parakeratosis, and further that Zn will prevent the occurrence of the disease.

THE VALUE OF DICYANODIAMIDE (CYANOGUANIDINE) IN A LOW PROTEIN DIET FOR WEANLING RATS. N. D. Magruder, E. W. Hartsook and R. W. Swift, *Pennsylvania State University.*

Three feeding trials with 66 weanling rats were used to study the value of dicyanodiamide (66.0 percent N) when added to a low protein diet. Pair-fed rats in two trials received the following diets: (1) a low protein basal (5.5 percent),

(2) basal + dicyanodiamide, (3) basal + dicy. + a commercial rumen microorganism preparation (rumenade), and (4) a normal (casein) protein diet. The latter three diets contained approximately 12.0 percent protein equivalent. The average body weight gains (gm.) and average body lengths (cm.) for the 6-week period were: (1) 54.4, 17.9; (2) 60.0, 18.1; (3) 60.3, 17.9; and (4) 90.7, 19.3. There were no significant differences between the first three groups. Bacteriological studies on the contents of the gastrointestinal tract revealed a higher total count in the rumenade group (3), however, morphological differences were not exhibited between treatments by the gram staining technique. Nitrogen balance trials conducted on all rats showed no differences between groups 1, 2 and 3. The amount of fat in the livers between rats fed the low protein diet and dicy. diet was the same. The restriction of food intake by the low protein group prompted an ad libitum feeding trial. Ten rats per group were fed (1) a low protein diet, (2) low protein + dicy., and (3) low protein + dicy. + rumenade. The results of this trial showed an increase in average body weight gains in diet 2 (63.1 gm.) and diet 3 (70.3 gm.) over the low protein control (53.2 gm.). The dicy. rats, however, consumed 5.9 percent more diet than the low protein rats and the rumenade rats consumed 4.5 percent more diet than the dicy. rats. Under the conditions of these experiments dicyanodiamide does not seem to have a place in the nutrition of monogastric animals. The relationship of these studies with swine will be discussed.

THE INFLUENCE OF CHLORTETRACYCLINE (AUREOMYCIN) ON THE PANTOTHENIC ACID REQUIREMENT OF WEANLING PIGS. J. I. McKigney, H. D. Wallace and T. J. Cunha, *Florida Agricultural Experiment Station.*

Twenty-seven six weeks old weanling purebred Duroc pigs were allotted to three groups according to sex, litter and weight and fed ad libitum in individual concrete pens which were washed daily. Group 1 received a 14 percent protein corn-soybean oil meal (expeller process) ration containing niacin, choline, riboflavin, pyridoxine, folic acid, vitamin A, vitamin B_{12} and minerals. Groups 2 and 3 received the same ration plus 6.2 mg. of pantothenic acid per pound and 10 mg. of chlortetracycline (Aureomycin) per pound, respectively. Part of the animals in each group were sacrificed after 47 days. The average daily gain, feed conversion factor and dressing percentage (minus head) for groups 1, 2 and 3 were: 0.95, 2.48, 65.3; 1.11, 2.42, 64.7; 1.22, 2.38, 67.1. For animals sacrificed on the 60th day, the same figures for groups 1, 2 and 3 were: 1.08, 2.48, 68.5; 1.24, 2.61, 71.5; 1.30, 2.57, 72.9. Cytochrome oxidase activity of the hearts (left ventricle) and livers (right central lobe) as determined with the Warburg respirometer indicated no consistent differences due to treatment. Microbiological assays of the adrenal, brain, heart, kidney and liver showed considerable variation between groups in pantothenic acid concentration per gram dry weight of tissue.

THE UTILIZATION OF UREA AND BIURET AS SOURCES OF NITROGEN FOR GROWING-FATTENING LAMBS. J. C. Meiske, W. J. Van Arsdell, R. W. Luecke and J. A. Hoefer, *Michigan State University.*

In a feeding trial involving fifty 75-pound lambs, a 7.13 percent crude protein basal ration was fed. The basal ration consisted of ground wheat straw, ground corn, molasses, dehydrated alfalfa meal, trace mineralized salt and dicalcium phosphate. Five lots of two replicate groups per lot were fed *ad libitum*. Three lots had either urea, biuret or crude biuret added to the basal ration increasing the crude protein analyses to about 9.10 percent. Soybean oil meal replaced part of the corn in the ration of lot 5, bringing the crude protein level up to about 9.7 percent. All rations were approximately equal in energy content. Adding either urea, biuret or crude biuret, or replacing part of the corn with soybean oil meal, signifi-

cantly increased the average daily gain and feed efficiency of the lambs. No significant differences were noted among the lots fed the various supplemental nitrogen sources. Under the conditions of this experiment, urea, biuret and crude biuret are satisfactory sources of supplemental nitrogen for growing-fattening lambs. Limited toxicity studies involving urea and biuret were carried out with sheep. Biuret appears to be less toxic than urea when fed in large amounts.

PHOSPHORIC ACID AS A SOURCE OF PHOSPHORUS FOR RUMINANTS. C. S. Menzies, D. Richardson, F. H. Baker and R. F. Cox, *Kansas State College.*

Forty Hereford heifer calves averaging 515 lb. were divided into lots of 10 each to study phosphoric acid as a source of phosphorus for ruminants. The animals were wintered on dry bluestem grass plus 1.5 lb. soybean oil meal and 0.2 lb. blackstrap molasses daily. Lot 1 was the control, lot 2 received 8 gm. of phosphorus daily from steamed bone meal, lots 3 and 4 received 8 and 4 gm., respectively, of phosphorus from phosphoric acid. Phosphoric acid, mixed in molasses, was added to the soybean meal. Average daily gains for the wintering phase of 162 days were 0.41, 0.42, 0.48, and 0.53 lb. for lots 1, 2, 3, and 4, respectively. Average serum phosphorus level of approximately 9 mg. percent at the start of the experiment was maintained throughout the wintering phase except in lot 1, which dropped to 6.12 mg. percent in February. All animals remained on pasture for spring and early summer grazing, with no supplement during this phase. Average daily gains for the 68-day grazing phase were 2.13, 2.30, 2.15, and 2.20 lb. for lots 1, 2, 3, and 4, respectively. After grass began to grow, the serum phosphorus level of lot 1 gradually increased to approximately that of the other lots. In a phosphorus balance study with lambs using a control ration containing 1.96 gm. of phosphorus, 0.32 gm. was retained. Adding 1 gm. phosphorus from phosphoric acid increased retention to 0.46 gm. Phosphoric acid supplements were highly palatable and produced no ill effects.

HISTIDINE AND LEUCINE REQUIREMENTS OF THE WEANLING PIG. E. T. Mertz, D. C. DeLong, D. M. Thrasher and W. M. Beeson, *Purdue University.*

The basal ration for the histidine studies contained 65 percent corn, 22 dextrose, 4.24 mineral, 5.26 essential amino acids (excepting histidine), 3.00 diammonium citrate, 0.5 liver extract powder, vitamins, chlortetracycline (10 mg. per lb. feed), 0.1 histidine, and 13 percent crude protein. L-histidine $\cdot$ HCl $\cdot$ H_2O was added to supply the following levels of histidine: Lot I, 0.1 percent; Lot II, 0.2; Lot III, 0.3, and Lot IV, 0.4 percent. In the first 28-day experiment the average daily gain (3 pigs per lot, av. starting wt., 30 lb.) was 0.84, 1.08, 1.16 and 0.93 lb., respectively. In the second 28-day experiment, the average daily gain (4 pigs per lot, av. starting wt., 33 lb.) was 0.65, 0.92, 0.98 and 0.95 lb., respectively. The leucine basal ration contained 13 percent crude protein and was similar to the histidine ration except ground wheat replaced the corn, and dextrose, purified amino acids, and diammonium citrate were adjusted accordingly. In the first leucine experiment the basal ration contained 66 percent wheat and 0.42 leucine, and in the second experiment 47 wheat and 0.3 percent leucine. L-leucine was added to supply the following levels of leucine: Experiment 1: Lot 1, 0.5 percent, Lot II, 0.6, Lot III, 0.7, and Lot IV, 0.8 percent. In 28 days the average daily gains for Exp. 1 (3 pigs per lot, av. starting wt., 37 lb.) were 0.90., 1.07, 1.00 and 1.03 lb., respectively. In experiment 2 the leucine levels were: Lot I, 0.3 percent, Lot II, 0.4, Lot III, 0.5 and Lot IV, 0.6 percent, and the average daily gains (28 days, 4 pigs per lot—av. starting wt., 25 lb.) were respectively 0.19, 0.50, 0.54 and 0.83 lb. Feed efficiency and appetite were significantly depressed when inadequate levels of histidine and leucine were fed. The data indicate that the L-histidine requirement is 0.2 percent, and the

L-leucine requirement is 0.6 percent, on a diet containing 13 percent crude protein. These studies complete the initial quantitation of essential amino acids for the weanling pig. A summary of requirements for the ten essential amino acids will be presented.

PERFORMANCE OF STEERS WITH OR WITHOUT STILBESTROL, WHEN FED TO A CONSTANT WEIGHT AND WHEN FED EQUAL AMOUNTS OF TOTAL CONCENTRATES. G. E. Mitchell, W. W. Albert, D. L. Staheli and A. L. Neumann, *University of Illinois.*

In most stilbestrol-feeding experiments involving beef cattle the feeding period for controls and treated animals have been of equal length and total feeds fed have been uncontrolled. Data were needed on control and stilbestrol steers fed to equal weights and/or when fed an equal amount of total concentrates. Three lots of 7 yearling Hereford steers each were fed as follows: lot 1—roughage, shelled corn, and protein supplement; lots 2 and 3—roughage, shelled corn and stilbestrol-protein supplement. The supplement fed to lots 2 and 3 furnished 10 mg. diethylstilbestrol per steer per day. Steers in lots 1 and 2 were fed to an average weight of about 1100 lb., while the steers in lots 1 and 3 were fed equal total concentrates during about the same length of time. Performance data for the three lots were: initial weights—859, 854, and 849 lb.; length of feeding periods—124, 96, 125 days; final weights—1106, 1100, and 1141 lb., daily gains—1.99, 2.56, and 2.34 lb.; concentrates per cwt. of gain—846, 665, and 719 lb.; feed costs per cwt. gain—$26.39, $21.29, and $22.63; weigh losses from feed lot to slaughter—27, 27, and 30 lb.; and dressing percentages on a cold carcass basis—64.39 percent, 64.44 percent and 63.42 percent. With ad libitum feeding, steers in lots 1 and 3 both consumed 16.8 lb. of concentrates per head per day or 1.49 percent and 1.48 percent of their average body weights. There were no significant differences in live grades. The only side effect observed was enlarged teats. Steers in lots 1 and 2 drank an average of 4.93 and 5.33 gal. of water per day during a 72-day period.

THE EFFECT OF PHENOTHIAZINE TREATMENT ON THE WINTER GAINS OF YOUNG BEEF CATTLE. W. A. Moyer, F. H. Baker, E. F. Smith, D. S. Folse and R. F. Cox, *Kansas State College.*

Two experiments were conducted to study the effect of phenothiazine treatment on the wintering performance of young beef cattle. The feeder calves used in the tests were purchased in southwest Kansas and northwest Texas where they had been grazing short, dry ranges. The stomach worm infestation as determined by egg per gram (E.P.G.) counts of composite fecal samples was relatively light at the beginning of the tests (156 and 17 eggs per gram of feces in the first and second experiments respectively). In the first experiment (winter 1953–54) five heifers in each six lots of 10 heifers were treated with 60 gm. of phenothiazine (two 30-gm. boluses). The same treatment was used for five steers in each of seven lots of 10 steers in the second experiment (winter 1954–55). The average daily gain of the 30 treated heifers and the 30 control heifers was 1.31 and 1.27 lb., respectively for 137 days of the first experiment. During the 140-day experimental period of the second test the average daily gains were 1.88 and 1.89 lb. for the 35 treated and 35 control steers, respectively. These differences in gain were not statistically significant.

THE EFFECT OF SUPPLEMENTARY FAT IN THE RATIONS OF LACTATING SWINE. Roland Norman, B. E. Sheffy and J. P. Willman, *Cornell University.*

Three experiments were conducted during successive farrowing seasons (1954–1955) including 39 purebred sows to determine the effect of different levels of supplemental fat on lactation performance of sows. The experimental design included the following treatments: basal, 7 percent fat, and 20 percent throughout the lactation period, 7 percent fat during the first 4 weeks and 20 percent fat during the last 4 weeks, and 20 percent fat during the first 4 weeks and 7 percent fat during the last 4 weeks of lactation. All rations contained 16 percent protein and were fed in dry lot. Weight gains of the litters, gain or loss of weight of the sows, milk fat content and overall feed efficiency were used as criteria of evaluation of the different treatments. The sows were milked at regular intervals and the litters weighed at these times. Differences in growth rate and feed efficiency between treatments in the spring and fall 1954 were not significant statistically. However, in spring 1955, the pigs grew faster ($P < 0.05$) and greater feed efficiency resulted ($P < 0.01$) from supplemental fat. No significant difference was noted in feed efficiency and growth of pigs on the change over design. The mean milk fat content of the basal, 7 percent and 20 percent fat fed sows were 6.73, 7.18, and 7.92 percent respectively. The sows maintained their weights better on the supplemental ration but little or no effect was exerted on the weaning weights of the pigs. Digestion coefficients (3 trials) for dry matter and fat respectively were: basal —78, 74; 7 percent—77, 85; 20 percent—84, 91.

THE IMPORTANCE OF MANGANESE FOR THE GROWTH AND REPRODUCTION OF SWINE. J. C. Outler, H. D. Wallace and G. K. Davis, *Florida Agricultural Experiment Station.*

The effect of two levels (3 and 100 p.p.m.) of dietary manganese on the growth and reproduction of Duroc swine was studied. The lower level of manganese depressed the early growth, although at maturity both groups were approximately the same size and weight. The level of manganese had no effect on the age of puberty of second generation boars and gilts. These boars were bred to test gilts and all proved fertile. All second generation gilts conceived at the first service during the second heat period and all farrowed normal pigs. However, pigs farrowed by the sows receiving the low level of manganese were in general weaker and the birth weights were approximately 30 percent lower. The level of manganese apparently had no effect on the survival of the pigs, although weekly comparison of pig weights showed the high manganese pigs to be heavier all through the lactation period. Total evaluation of growth, reproduction, and lactation for two generations will be presented as well as the manganese values for selected tissues of newborn pigs and their dams.

THE USE OF ANTIBIOTICS IN SELF-FEEDING LAMBS. Leonard V. Packett, Jr., J. H. Bridges, Marcus Hoelcher and H. O. Kunkel, *Texas Agricultural Experiment Station.*

Six feeding trials involving 494 feeder lambs were conducted to study the possibility of increasing gains and feed efficiency and reducing death losses by supplementing a self-fed ration with antibiotics. Chlortetracycline (Aureomycin) was tested at levels of 5–15 mg. per lb. of feed. In two trials oxytetracycline (Terramycin) was included at a level of 15 mg. Feed consumption was temporarily reduced by the inclusion of the antibiotic. In five of the trials lambs were self-fed a total-mix high concentrate ration (50–60 percent) from the onset of the trial.

The antibiotic supplemented lambs consistently gained as well or better than their controls; however, the differences were not significant statistically. Feed conversion in most trials was in favor of antibiotic supplemented lambs. Results of experiments with implants of 250 mg. progesterone and 10 mg. estradiol indicated no additive increase in gain with chlortetracycline, but an additive effect of efficiency of feed conversion was evident. Scouring in antibiotic supplemented lambs was less severe and of a shorter duration. The possible use of chlortetracycline to prevent enterotoxemia was suggested since throughout four years experimentation there were 10 deaths in 275 control lambs caused by enterotoxemia and no deaths from enterotoxemia in 373 chlortetracycline supplemented lambs. It is suggested that the greatest value of antibiotics in feeder lamb rations is that of a conditioner allowing greater ease of getting lambs on full feed.

A COMPARISON OF CITRUS PULP, CRACKED CORN AND GROUND SNAPPED CORN FOR FATTENING STEERS. F. M. Peacock and W. G. Kirk, *Range Cattle Station, Florida.*

Three feeding trials have been conducted, 1953, 1954 and 1955, to compare the value of citrus pulp, cracked corn and ground snapped corn for fattening steers. Four grade Brahman yearling steers were used in each lot except for the citrus pulp fed lot in 1953 when three animals were used. Length of each trial was 140 days. Rations tested consisted of either 70 parts citrus pulp, 70 parts cracked corn or 70 parts ground snapped corn plus 25 parts cottonseed meal and 5 parts alfalfa leaf meal. In addition, each ration included the same amount of Pangola hay and citrus molasses and steers had free access to a complete mineral. The results are averages for the three years. Steers fed citrus pulp: gain, 2.39 lb. per day; TDN, 448 lb. per 100 lb. gain; carcass grade, U. S. low good. Steers on cracked corn: gain, 2.42 lb. per day; TDN, 471 lb. per 100 lb. gain; carcass grade, U. S. good. Steers fed ground snapped corn: gain, 2.39 lb. per day; TDN, 442 lb. per 100 lb. gain; carcass grade, U. S. good.

UTILIZATION OF PHOSPHORUS FROM VARIOUS SOURCES BY GROWING-FATTENING SWINE. M. P. Plumlee, M. H. Kennington and W. M. Beeson, *Purdue University.*

In 3 feeding experiments with 5 or 6 weanling pigs per treatment, the following phosphorus supplements were compared: dicalcium phosphate (ppt.), steamed bonemeal, defluorinated rock phosphate, commercial monocalcium phosphate, imported rock phosphate, and soft phosphate with colloidal clay. A cerelose-casein basal ration containing 0.18 percent phosphorus and adequately supplemented with all other known nutrients was used. Each supplement was added to raise the total phosphorus to the desired levels. Each pig was individually fed *ad libitum*. At the 0.30 percent dietary phosphorus level, growth rate and feed efficiency were similar for all 6 supplements, however, crooked bones and skeletal weakness were more common, appeared earlier, and were more severe in the "soft phosphate" than any other group. Monocalcium phosphate and imported rock phosphate gave the best results of the 6 supplements tested simultaneously at the 0.30 percent level. "Soft phosphate" at either the 0.45 or 0.60 percent level markedly decreased growth rate during the critical first 6 weeks of the feeding period. The 0.60 percent level of "soft phosphate" produced excessive pitting and decay of the molars. Serum inorganic phosphorus values were similar for the different supplements at the same phosphorus level, but they increased with increases in dietary phosphorus. The utilization of P_{32} labeled calcium phytate isolated from corn grain by four 135-lb. barrows was also studied. The P_{32} was injected directly into the growing corn stalks. An average of 1.95 percent of the PO_4 phosphorus and 61.2 percent of the calcium phytate phosphorus was excreted.

INFLUENCE OF ADDED FAT ON HEATING IN ANIMAL FEEDS. Luther R. Richardson and John V. Halick, *Texas Agricultural Experiment Station.*

Studies were carried out on the effect of adding lard and Mazola on the growth of molds and heating in corn and soybean oil meals. When 10 percent of Mazola was added to corn meal containing 12.9 percent moisture, no heating occurred, but when the moisture content of the corn meal was above the critical level (13.5 to 15 percent) fat delayed the heating slightly at each moisture level. Each mixture eventually heated although its moisture content was below the critical level of the corn meal. A mixture composed of 90 percent of corn meal with 13.5 percent moisture and 10 percent of Mazola heated even though the mixture contained only 12.3 percent moisture. In another study 10 and 15 percent of Mazola were added to corn meal containing 13.6 percent of moisture. The mixtures contained 12.1 and 11.5 percent moisture respectively, and both mixtures heated at essentially the same time as the corn meal without fat. Similar results were obtained with mixtures of corn meal and lard and with mixtures of soybean oil meal and Mazola. These data show that the addition of fat to a feed ingredient will delay heating at any moisture level, but the mixture will eventually heat when the moisture content of the hygroscopic ingredient is above the critical level, regardless of the amount of fat present. There is no evidence that the addition of fat or an unsaturated fatty oil such as Mazola will increase the susceptibility of an ingredient to heating.

LYSINE REQUIREMENT OF THE GROWING RAT AS A FUNCTION OF THE PRODUCTIVE ENERGY LEVEL OF THE DIET. Hans R. Rosenberg and R. Culik, *Stine Laboratory, E. I. du Pont de Nemours and Co.*

Earlier this year we have shown that the methionine requirement of the chick, expressed as percent of diet, cannot be considered a fixed value but increases as the productive energy level of the diet is increased. This concept should apply to most nutrients and to all animals. The existence of a lysine-energy relationship postulated according to this concept has been studied using the rat as the experimental animal. Initially a 14 percent protein, low-lysine ration based on wheat products was used at two energy levels differing by 200 Cal. per lb. Groups of weanling rats were fed these diets supplemented with graded levels of lysine·HCl for 5 wk. In three trials, the amount of supplementary lysine·HCl above which growth and efficiency of food utilization was not significantly improved differed by 0.2 percent for the two diets. Thus, the principle of the postulated concept was confirmed. A practical-type hog ration based on corn, cottonseed meal and wheat flour middlings and containing 14 percent protein was investigated next. In three experiments optimum performance of the males was obtained when the diets were supplemented to contain 0.63 percent lysine at 900 and 0.71 percent lysine at 1000 Cal. per lb. On the basis of these responses a tentative lysine-energy requirement line has been drawn. The lysine requirement of the female rat on these diets is apparently somewhat smaller, about 0.08 percent less than that of the male at all energy levels studied. This work provides a rational basis for investigating the value of lysine supplementation of practical pig rations.

THE EFFECTS OF SOME FACTORS ON BLOOD FAT LEVELS IN SWINE. H. L. Self, *University of Wisconsin.*

Blood fat levels were studied in 61 pigs of Chester White or Poland China breeding. Barrows and gilts of both breeds were allotted to a ration containing either peanut meal or soybean meal. These two groups were further divided to allow one half under each protein-source group to receive 12 percent protein and the other half 16 percent. Within each of those protein-percentage groups, a further

division was made so that one-half of all animals received antibiotics and one-half received no antibiotics in the ration. Beginning on July 13, 1954, when all pigs were between the 120th and 130th day of age, 15 to 20 ml. samples of whole blood were taken at 3-week intervals to determine the effects of age, weight, sex, breed and nutrition upon the blood-fat level of swine. The method of Allen was used. Those on a 12 percent protein ration had higher blood-fat levels (179 mg. percent) than those on 16 percent protein (164 mg. percent) ($P < 0.05$). Antibiotic-fed pigs had 180 mg. percent as compared to 163 mg. percent for those not receiving antibiotics ($P < 0.05$). There were no significant interactions among the several factors under study. An analysis of covariance to determine the relationship between age, weight, and blood fat is incomplete at present.

AN EVALUATION OF VARIOUS BLENDS OF SOYBEAN OIL MEAL, PEANUT OIL MEAL AND DEGOSSYPOLIZED COTTONSEED MEAL AS PROTEIN SUPPLEMENTS IN SWINE RATIONS. R. F. Sewell, B. C. Keen and J. L. Carmon, *University of Georgia.*

Twelve outcome groups of five pigs each were randomly allotted in replicate to six treatments designed to study the efficiency of various blends of three different sources of plant protein when used to supplement a corn ration for growing swine. The substitution ratios employed were: (1) Soybean oil meal alone; (2) Three-quarters soybean oil meal plus one-quarter peanut oil meal; (3) One-half soybean oil meal plus one-half peanut oil meal; (4) One-quarter soybean oil meal plus three-quarters peanut oil meal; (5) One half soybean oil meal plus one-half degossypolized cottonseed meal; (6) One-third soybean oil meal plus one-third peanut oil meal plus one-third degossypolized cottonseed meal. The balance of the rations were composed of yellow corn, dehydrated alfalfa meal, and fortified with vitamins and minerals. All rations were equated with respect to protein content. Average daily gains and feed conversion figures for the six treatments were as follows: (1) 1.68, 3.23; (2) 1.57, 3.55; (3) 1.71, 3.54; (4) 1.70, 3.51; (5) 1.54, 3.42; (6) 1.62, 3.56. Statistical analysis of the data revealed no significant differences between any of the treatments with respect to either growth rate or efficiency of feed utilization. Growth performance and feed conversion were satisfactory in all treatment groups.

THE EFFECT OF DIFFERENT LEVELS OF FIBER, FAT AND KIND OF FAT ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FATTENING PIGS. B. E. Sheffy, R. L. Holmes, L. C. DeCosta and J. P. Willman, *Cornell University.*

Two experiments involving 80 growing-fattening pigs were conducted to evaluate levels and types of waste animal fat fed in combination with different levels of roughage so as to maintain equal energy and protein contents. Growth, feed efficiency, carcass quality and digestibility were used as criteria of evaluation. The treatments (1st replicate) were as follows: A. Basal—5 percent roughage, B. 3 percent yellow grease—12.5 percent roughage, C. 6 percent yellow grease—23.5 percent roughage, D. 10 percent yellow grease—37 percent roughage. The same treatments were used in the 2nd replicate except for duplicate lots of B, C, and D. At average weights of 125 lb. one of each of the duplicate lots was fed a similar ration except that a hydrogenated dry tallow (HT) replaced the yellow grease (YG). Average daily gains and feed efficiency were: 1st replicate A. 1.50, 373.5 B. 1.66, 344.8; C. 1.53, 393.0; D. 1.45, 397.9. 2nd replicate B. (YG) 1.56, 342.2; (HT) 1.64, 350.2; C (YG) 1.41, 360.4; (HT) 1.30, 375.6; D. (YG) 1.23, 345.6 (HT) 1.05, 391.9. Increases in roughage content over 12.5 percent resulted in slower growth even when the energy content of the ration was kept constant

by addition of fat. Hydrogenated fat did not appear to be as efficiently utilized as yellow grease, particularly when fed at higher levels. Digestibility of the dry matter, protein and crude fiber decreased as levels of fat and roughage increased. The firmness of the carcasses tended to decrease as the levels of fat and roughage increased.

EFFECT OF DIFFERENT LEVELS OF SUPPLEMENTAL WINTER FEED AND AGE AT FIRST CALVING ON THE PERFORMANCE OF RANGE BEEF COWS. J. D. Shroder, L. S. Pope, Dwight Stephens and Robert MacVicar, *Oklahoma Agricultural Experiment Station.*

Presented are seven years data with 120 grade Hereford cows in a long-time study at the Ft. Reno station. In the fall of 1948, the cows started the experiment as weaner heifer calves. They have grazed native grass pastures (bluestems) year-long, with three different levels of supplemental winter feed from November to mid-April: Low (1.0 lb. of cottonseed oil meal (C.S.) per head daily), medium (2.5 lb. C.S. meal) and high (2.5 lb. of C.S. meal + 3.0 lb. of oats). In addition, one-half of the heifers in each group were bred to calve first as two-yr.-olds, the remainder as three years. Data obtained include the 5th and 6th calf crops. Results indicate that winter weight loss was inversely related to the level of supplement fed. In most cases, however, summer gains were such that most of the difference in winter weight loss was recovered, resulting in little difference in body weight from fall to fall. Weight losses among the low level cows became less severe as they approached maturity. A combination of low level of wintering and two-yr.-old calving retarded growth and resulted in a smaller cow at maturity. However, to date there has been no significant difference in number of calves weaned, or weaning weights. Total feed and pasture costs have been 35 percent greater for the medium level, and 85 percent greater for the high level, than for the low level of wintering. At 7.5 years of age, cows that calved first as two-yr.-olds have weaned approximately .8 more calf than their mates which calved first as three years.

THE EFFECT OF FEEDING LAMB FATTENING RATIONS AS WHOLE GRAINS OR PELLETS. O. O. Thomas, J. L. Van Horn, T. S. Aasheim and A. S. Hoversland, *Montana Agricultural Experiment Station.*

Three lamb-fattening tests, conducted from 1952 through 1954, were designed to test three rations commonly fed to lambs in Montana and to test the value of the same ration when fed as whole grains or pellets. Lambs of Columbia, Rambouillet, and Targhee breeding were used in these trials. Of three rations tested in 1952, one consisting of one-third each of barley, oats, dried molasses beet pulp, and alfalfa hay fed free-choice gave the best results; alfalfa formed 35 percent of the total daily ration consumed by lambs fed this ration. In 1953, 186 lambs were fed and in 1954, 90 lambs were fed. All rations were self-fed and two lots of lambs were fed each ration. Ration 1 consisted of whole grains and alfalfa hay (ration described above); ration 2 consisted of a grain pellet (30 percent each of barley, oats, dried molasses beet pulp and 10 percent molasses) and alfalfa hay; and, ration 3 consisted of a completely pelleted ration (about 18 percent each of barley, oats, dried molasses beet pulp, 35 percent alfalfa hay, and 10 percent molasses). In the 1953 trial, the average daily gains for lambs fed rations 1, 2, or 3 were 0.36, 0.42, and 0.41 lb., respectively. Lambs fed rations 2 or 3 gained faster, sold for a higher price, and carcasses graded higher than lambs fed ration 1; however, because of the added cost of pelleting, lambs fed these pelleted rations returned less than lambs fed whole grains. In the 1954 trial, the average daily

gains of lambs fed rations 1, 2, or 3 were 0.41, 0.45, and 0.48 lb., respectively. The difference between gains of lambs fed rations 1 and 3 was significant at the 10 percent level of probability but not at the 5 percent level.

DIGESTIBILITY OF AMMONIATED CANE MOLASSES AND THE UTILIZATION OF ITS NITROGEN BY CATTLE AND SHEEP. Allen D. Tillman, Willis D. Gallup and George A. McLaren, *Oklahoma Agricultural Experiment Station.*

In Experiment 1 with steers, (A.C.M.) ammoniated cane molasses (16 percent protein equivalent) was compared with cottonseed meal (42 percent) when each supplied 10 percent of the concentrate nitrogen in iso-caloric and iso-nitrogenous fattening-type rations containing 12 percent protein. Digestion coefficients were 64 and 66 for total protein and 78 and 79 for organic matter in the A.C.M. and cottonseed meal rations, respectively. N retentions expressed as percentages of total N intake were 11.4 and 15.4, respectively. In Experiment 2 with steers, digestibilities of two A.C.M. products (16 and 33 percent protein equivalent) were determined using the "by difference" procedure. Each product supplemented equal amounts of prairie hay to form iso-nitrogenous rations. Digestion coefficients were 60 and 58 for protein and 80 and 82 for organic matter in the 16 and 33 percent products, respectively. In Experiment 3 with steers, the effect of the 16 percent product on digestion of prairie hay was compared with that of two levels of regular cane molasses. Both levels of molasses (1.5 and 3 lb. per day) decreased fiber digestion; the A.C.M. product (1.5 lb. per day) did not. In Experiment 4 and 5 with sheep, the 33 percent product was added to basal rations containing 5.4 and 10 percent protein. Nutrient digestibilities were calculated "by difference." About 49 percent of the A.C.M. nitrogen added to the low protein ration was apparently digested, and of this, 72 percent was retained. Only 34 percent of the N added to the higher protein ration was apparently digested, and, of this, 39 percent was retained.

GROWTH, FEED EFFICIENCY, AND CARCASS DESIRABILITY OF SWINE AS AFFECTED BY LEVEL OF PROTEIN, CHLORTETRACYCLINE (AUREOMYCIN) AND FEED INTAKE. L. F. Tribble and W. H. Pfander, *University of Missouri.*

Two trials, involving 128 crossbred pigs, were conducted to determine the effects of level of protein, 16 percent (HP) and 12 percent (LP), chlortetracycline, (0 or 18 mg. per lb. feed) and level of feed intake, full fed (FF) and limited fed (LF) to 85 percent of a full feed, on growth, feed efficiency and carcass desirability.

There was no difference in rate of gain or feed efficiency for the pigs on the two levels of protein for the entire feeding period. From weaning to 100 lb., the pigs on HP made 12.7 percent faster gains than those on LP ($P < .01$), but from 100 to 200 lb. the pigs on LP made 6.5 percent faster gains than those on HP ($P < .01$). The addition of chlortetracycline increased the rate of gain of the pigs 6 percent ($P < .05$) over pigs fed a ration containing no antibiotic. Pigs receiving antibiotic gained significantly faster up to 100 lb. but did not gain significantly faster from 100 to 200 lb. Limiting the feed intake reduced the rate of gain 26.7 percent ($P < .01$) as compared to gains made by FF pigs. However, the LF pigs made 5.2 percent more efficient gains than FF pigs ($P < .05$). Carcass data and live hog backfat probes at 150 and 200 lb. were obtained on one-half of the hogs. Pigs fed HP produced carcasses that contained 1.6 percent more lean cuts and 4.5 percent less fat than pigs on LP. LF pigs produced carcasses that contained 2.8 percent more lean cuts and 6.3 percent less fat than FF. Antibiotic had no apparent effect on carcass composition.

THE EFFECT OF ORGANIC ARSENICALS, CHLORTETRACYCLINE (AUREOMYCIN) and LINSEED OIL MEAL ON SELENIUM POISONING IN SWINE. R. C. Wahlstrom, L. D. Kamstra and O. E. Olson, *South Dakota State College.*

Three trials were conducted to study the value of organic arsenicals, chlortetracycline and linseed oil meal in counteracting selenium toxicity in swine. In Trial I 48 weanling pigs were allocated to six treatments (1—soybean oil meal + 13 p.p.m. selenium; 2—linseed oil meal + selenium; 3—As 1 + .005 percent 3-nitro-4-hydroxyphenylarsonic acid; 4—As 2 + .005 percent 3-nitro-4-hydroxyphenylarsonic acid; 5—As 1 + .01 percent arsanilic acid; 6—As 2 + .01 percent arsanilic acid). The average daily gains for the 84-day trial were 0.99, 0.99, 1.25, 1.22, 1.24 and 1.19 lb., respectively. Linseed oil meal appeared to prevent the symptoms of selenium toxicity as nine pigs receiving the soybean oil meal rations developed selenium toxicity symptoms while only one of the pigs fed linseed oil meal showed these symptoms. In Trial II five lots of 8 pigs each were fed as follows: Lot 1, basal; Lot 2, basal + 10 p.p.m. selenium; Lot 3, As 2 + .01 percent arsanilic acid; Lot 4, As 2 + 5 mg. chlortetracycline per lb.; Lot 5, As 4 + .01 percent arsanilic acid. The average daily gains were 1.33, 1.13, 1.31, 1.45 and 1.48 lb., respectively. The gains of three pigs from lot 4 are not included, two pigs were removed because of severe emaciation and selenium symptoms and one pig died of unknown causes. The combination of antibiotic and arsanilic acid prevented all visible selenium toxicity symptoms as well as producing the best growth rate. In a third trial two lots of 8 pigs were fed a ration containing seleniferous grains. One lot served as a control and the other lot was fed .01 percent arsanilic acid. The pigs receiving the arsanilic acid made a faster rate of gain especially during the early part of the experiment.

A LONG TIME STUDY ON THE FEEDING OF CHLORTETRACYCLINE (AUREOMYCIN) TO GESTATING-LACTATING SOWS. H. D. Wallace, *Florida Agricultural Experiment Station.*

A study has been completed to determine the long-time effect of adding chlortetracycline at the rate of 40 gm. per ton to the ration of gestating-lactating sows fed on good grass and legume pastures. First, second, third, fourth and fifth litter performances indicate that the antibiotic-supplemented sows have farrowed slightly heavier pigs, weaned slightly fewer pigs and weaned less total weight per litter. There is no clear evidence from the experiment that the antibiotic has been either detrimental or beneficial over this long time feeding period.

THE EFFECT OF VARYING LEVELS OF PROTEIN AND CERELOSE ON THE UTILIZATION OF MATURE TIMOTHY HAY BY SHEEP. Walter R. Woods, Charles M. Thompson and Robert B. Grainger, *Kentucky Agricultural Experiment Station.*

A series of three metabolism trials were conducted with 18 wether lambs weighing about 75 lb. each in a 3×3 factorial design. Low quality timothy hay was supplemented with adequate amounts of soybean meal to raise the crude protein of the ration to about 6.9, 10.9 and 13.6 percent. Cerelose was added in amounts of 0, 3.3, and 6.2 percent of the ration. The percent apparent digestibility of ration constituents for the 6.9, 10.9 and 13.6 percent protein rations respectively was as follows: dry matter 52.2, 55.1, 59.3; organic matter 52.7, 55.8, 59.8; crude protein 50.7, 69.1, 76.1; nitrogen free extract 57.4, 58.9, 62.2; energy 49.3, 52.5 and 57.5. The daily nitrogen balance (gm.) in the same order was -0.60, -0.11 and $+0.22$. These data differ significantly. Increasing the protein level from 6.9 to 13.6

percent had no significant effect on the apparent digestibility of crude fiber. The addition of cerelose at either 3.3 or 6.2 percent did not significantly affect the apparent digestibility of dry matter, organic matter, crude fiber or digestible energy. Cerelose added at 6.2 percent reduced the apparent crude protein digestibility at all levels of protein studied. The crude protein digestibility for 0 and 6.2 percent of added cerelose was 50.7, 47.7; 69.1, 66.0; 76.1 and 73.8 for the 6.9, 10.9 and 13.6 percent protein rations respectively. These data are highly significant. There was a highly significant increase in the apparent digestibility of nitrogen free extract due to cerelose additions.

Meats Section

L. E. Walters, *Chairman*

HARDENING PEANUT-FED PIGS BY FINISHING WITH INEDIBLE BEEF TALLOW IN A HIGH PROTEIN RATION. R. H. Alsmeyer, A. Z. Palmer, H. D. Wallace, R. L. Shirley and T. J. Cunha, *Florida Agricultural Experimental Station.*

Thirty-nine crossbred pigs were placed in five lots according to weight, sex and age. The average initial and average final weights for all lots were 60 lb. and 210 lb., respectively. Feeding was on pasture. Lot I was hand-fed peanuts in the shell from the initial to the final weight. Lots II, III and IV were hand-fed peanuts in the shell from initial weight to 170, 150 and 130 lb., respectively and then self-fed a "hardening" ration to final weight. Lot V was self-fed a corn-soybean oil meal ration from initial to final weight. Representative animals were slaughtered at 130, 150 and 170 lb. to determine carcass firmness effects of peanut feeding for 70, 90 and 110 lb. of gain, respectively and to determine the effectiveness of the "hardening" ration in firming up pork. The hardening ration contained 18 percent crude protein and 15 percent inedible beef tallow. Carcasses from Lot I graded oily. Carcasses from Lots II, III and IV graded proportionate to the number of pounds of gain made on the "hardening" ration that followed peanut gain. Iodine numbers corresponded to physical grades and were influenced by the number of pounds of gain made on the "hardening" ration. Triglyceride composition of depot and body fats varied according to the feeding treatment.

A COMPARISON OF TWO METHODS OF DETERMINING PORK CARCASS CUT-OUT VALUE. D. E. Brady, A. M. Mullins, L. Tribble and J. F. Lasley, *Missouri Agricultural Experiment Station.*

An important consideration in all livestock production is a relatively simple but equitable evaluation of the end product. Presented is a comparison of two methods developed for expressing live hog and carcass values based on cut-out yields. In the "adjusted loin equivalent" value, the yield is expressed on the basis of the trimmed loin and converted to a dollar value basis. In the "discount" method, the prices of wholesale cuts and trimmings are adjusted on the basis of grade and quality score.

Carcasses with 1.1 to 1.5 inches of back fat and No. 1 quality, had a higher value than those of 1.5 to 1.8 inches of back fat. On the live weight basis, the hogs with 1.5 to 1.8 inches of back fat were higher in value. Carcasses with 1.1 inches of back fat but No. 2 quality had the highest yield of the four lean cuts and the highest cut-out value regardless of the discount. The Choice II grade

carcasses were lowest in value which was reflected in the live hog value. The "adjusted loin equivalent" values approximated the actual cut-out value, except for the Medium grade No. 2 quality carcass where the value is high. The data were obtained from 273 hogs produced at the Missouri Station and slaughtered at approximately 200 lb. live weight.

COMPARATIVE EVALUATION OF TECHNIQUES USED IN ESTIMATING BEEF CARCASS QUALITY. B. C. Breidenstein, Sleeter Bull, R. M. Forbes and J. R. Stouffer, *University of Illinois.*

A total of 24 steers, ranging in carcass grade from High Good to Low Prime, were used in this study. Attempts were made to measure objectively some of the traits that have been previously evaluated only subjectively. The following techniques were used and comparisons of methods were made in several instances; body fat content was measured by the antipyrine technique; carcass fat content was estimated by specific gravity of the wholesale rib cut, physical separation of the wholesale rib, and determination of the ether extract of the separable lean and fat of the wholesale rib; marbling was measured by specific gravity and ether extract of the longissimus dorsi muscle of the wholesale rib; color of lean and fat were determined by the spectrophotometer; carotene assay was used as an index of color of the external fat, and; firmness of the external fat was measured by iodine number, refractive index, and Wiley melting point. The following results were obtained: the antipyrine technique was extremely inconsistent; the various indices of carcass fatness were in excellent agreement; little relationship appeared to exist between the subjective valuation of marbling and the specific gravity of the rib eye whereas the ether extract of the rib eye seemed to show positive relationship with marbling; the spectrophotometer seemed to provide a reliable measure of color of both fat and lean; iodine number and refractive index were in rather good agreement as a measure of fat firmness, but the Wiley melting point did not agree very closely with either of the other two measures.

SLAUGHTER AND CARCASS CHARACTERISTICS OF OLD COWS AFTER DRY LOT FATTENING. O. D. Butler, J. K. Riggs, R. L. Reddish, G. T. King and N. R. Ellis, *Texas A. & M. College.*

Slaughter and carcass studies were made on thirty-three grade Hereford cows which were fed for periods of 78 and 112 days and five slaughtered without feeding. These cows were part of a lot of 72 old thin cows purchased on the San Antonio Stock Yards. Average initial weight was 792 lb. The fed groups were divided into four lots and fed a ration containing 51, 44, 36 and 41 percent concentrates. A level of 5.4 percent stabilized inedible animal fat was incorporated into the ration of Lot IV. All lots made good gains, with Lot IV being the highest. Average daily gains in pounds for each lot were 2.60, 2.48, 2.83 and 2.92. Dressing percentages for all lots were good and increased as fatness and length of feeding period increased. Dressing percentage adjusted to open cow basis was 52.95 for the five unfed cows. Average adjusted dressing percentages for the four lots fed 78 days were 54.35, 53.66, 53.25 and 55.56, respectively. Cows fed 112 days had average adjusted dressing percentages of 58.44, 56.35, 55.58 and 54.79. The unfed cow carcasses averaged low cutter. All carcasses from the cows fed 78 days graded low utility, except Lot IV which graded average utility. The longer fed cow carcasses graded high utility for Lots I and III, and low commercial for Lots II and IV. Percent of loin, rib and round (rump on) was 50.17 for the unfed cows, 48.09 for 78 day fed group and 47.84 for the 112-day fed group.

SLAUGHTER AND CARCASS DIFFERENCES BETWEEN BRAHMAN AND BRAHMAN-SHORTHORN CROSSBRED STEERS. J. W. Carpenter, A. Z. Palmer, W. G. Kirk, F. M. Peacock and M. Koger, *Florida Agricultural Experiment Station.*

Slaughter and carcass characteristics of 47 steers of purebred Brahman, ¾ Brahman-¼ Shorthorn, ½Brahman-½ Shorthorn, and ¼ Brahman-¾ Shorthorn breeding were investigated over a three year period. Steers with a predominance of Brahman breeding differed significantly from ½ Brahman-½ Shorthorn and ¼ Brahman-¾ Shorthorn steers by having smaller digestive tracts, smaller livers, heavier hides, greater length of hind leg, a higher combined percentage of high priced primal cuts (round, rib and loin) and a higher cooler shrink. One half and three quarter Shorthorn steers graded significantly higher on the rail, had larger kidney knobs and a higher percentage of fat in the prime rib. Differences in dressing percentage and in percentage of head, pluck, chuck, shank, brisket, short loin, flank, fore and hind quarters and amounts of bone and connective tissue were not significant. Organoleptic and shear test values on cooked steaks and roasts showed the purebred Brahman and the three quarter Brahman steers to be less tender than the one half and three quarter Shorthorn steers. The metacarpus and metatarsus bones of sixteen steers, slaughtered at approximately 14 months of age, were tested for differences in bone breaking strength. Breaking strengths were significantly higher for ¾ Brahman and purebred Brahman groups compared to steers of ½ and ¾ Shorthorn groups.

PRESERVATION OF CARCASSES BY INJECTION OF ANTIBIOTICS BEFORE SLAUGHTER. H. E. Downing, W. B. Hardie, J. R. McMahan, D. Billman and H. G. Luther, *Chas. Pfizer & Co., Inc.*

A study was made to determine the most economical method of preslaughter treatment of carcasses in order to retard spoilage and permit hanging at higher temperatures, thus shortening aging time. Preliminary trials with sheep were directed toward determining the minimum intraperitoneal dose and the optimum time prior to killing to inject the antibiotic in order to produce maximum blood and tissue levels at the time of slaughter. In sheep, 1 to 3 mg. of oxytetracycline (Terramycin) per lb. of body weight was as effective as higher levels and maximum tissue levels were achieved by injecting 1 to 2 hours before slaughter. Bacteriological examination of carcasses hung without refrigeration showed that deep tissues in oxytetracycline-treated ones remained bacteria-free longer than those of the untreated. Information on retention of antibiotics in refrigerated and cooked tissues is presented. The intraperitoneal method of introducing an antibiotic as a carcass preservative appears to be easier than the infusion method and gives more complete distribution.

COMPOSITION OF UNCURED BACON AND FINISH IN DRESSED HOG CARCASSES. R. L. Hiner, *Animal & Poultry Husbandry Research Branch, U.S.D.A.*

A study has been made of the relationship between certain factors in uncured bacon and some of the more desirable meat characteristics in the dressed hog carcass. The statistical analysis was made on data from fresh, trimmed bacons from 47 hogs slaughtered at a final feed-lot weight of 225 lb. that varied widely in fatness, length and depth as follows: area in square inches of the lean in cross-section at the sixth rib; area of fat at same location; weight of bacon; thickness of back-fat; weight and percentage of lean and fat in the entire side and average thickness of bacon. The following correlation coefficients, significant at the one percent level, were found: area of lean as percent of total area of bacon

and weight of lean as percent of total weight of bacon +0.58; average thickness of back-fat and weight of lean as percent of total weight of bacon —0.61; area of fat as percent of total area of bacon and weight of fat as percent of total weight of bacon +0.61; average thickness of back-fat and weight of fat as percent of total weight of bacon +0.63; average thickness of bacon and yield of bacon (percent of slaughter weight) +0.50; and weight of separable fat in trimmed bacon and weight of separable fat in ham +0.49. Estimating equations have been determined for each of the factors studied. This information will be useful in evaluating leanness and other quality factors of bacon as they relate to certain carcass characteristics that can be obtained with relative ease and accuracy.

PERFORMANCE AND CARCASS CHARACTERISTICS IN INDIVIDUALLY FED STEER AND HEIFER CALVES. Amos P. Kennedy, G. A. Branaman, G. A. Brown, O. G. Hankins and W. D. Baten, *Michigan State University and U.S.D.A.*

Hereford steer and heifer calves from the same herd were full-fed individually in three experiments and slaughtered at four times 50 days apart, beginning after 121 days feeding. Slaughter grades as used prior to 1950 varied from Good to Low Prime. Fatness, as measured by slaughter grade, carcass grade, carcass separable fat, and ether extract in boneless meat, was similar in the two sexes when the steers were fed 50 days longer than the heifers. Most production factors and other carcass characteristics were also similar at the same fatness. Heifer gains slowed down after 84 days, while steer gains which had been similar to heifers were maintained for 140 days, and dropped more slowly than heifers. Rate of gain, feed consumption and feed efficiency were higher in steers when cattle of both sexes were slaughtered at the same time, but no significant differences were found when heifers were matched with the next later kill of steers. Degree of finish had no significant effect on percentages of wholesale loin, rump, chuck or plate. Heifers had slightly higher percentages of hindquarter and flank, and also higher meat to bone ratios in the carcass, both by kills and at the same finish. Steers had more forequarter, chuck, shank and carcass bone as percentages of carcass. When matched for finish, no significant differences were found in the wholesale cuts of loin, rib, round, rump or plate, as percentages of carcass.

PHYSICAL, CHEMICAL AND ORGANOLEPTIC CHARACTERISTICS OF BEEF RIBS AS INFLUENCED BY CITRUS FEED. W. G. Kirk, E. R. Felton, H. J. Fulford and George K. Davis, *Range Cattle Experiment Station, Florida.*

Twenty-eight grade steers, predominately Brahman-Shorthorn breeding, were fed individually for 120 days. The check ration fed lot 1 consisted of hay, cottonseed meal and ground snapped corn. In Lots 2 and 4, dried citrus pulp and fresh grapefruit replaced the ground snapped corn. Lot 3 was given dried citrus pulp and 2 lb. ground snapped corn while Lot 5 received fresh grapefruit and 2 lb. ground snapped corn daily per steer. Average carcass grades varied with the energy level of the rations, ranging from U. S. Commercial for steers fed fresh grapefruit, Lot 4, to U. S. Good for Lot 1, fed ground snapped corn and Lot 3, receiving a combination of citrus plup and corn. The prime rib cuts, 9th, 10th and 11th ribs, were taken for meat studies; right side for physical separation and chemical analysis and left side for organoleptic tests. Physical separation showed the average percentage of eye ranging from 22.8 percent in Lot 1 to 26.3 percent in Lot 2. The average fat content of the eye ranged from 4.8 percent for steers fed fresh grapefruit, Lot 4, to 6.9 percent for Lot 3, fed citrus plup and ground snapped corn. The average pull to shear 1 inch cores from the cooked eye ranged from 19.7 lb.,

Lot 4, fed grapefruit, to 24.2 lb. for animals fed grapefruit and corn, Lot 5. There were no indications that the rations fed affected either the percentage of eye or fat content and tenderness of the eye.

THE EFFECT OF CHILLING TIME ON THE SPECIFIC GRAVITY OF HOG CARCASSES AND UPON THE CORRELATION BETWEEN SPECIFIC GRAVITY AND MEASURES OF FATNESS. E. A. Kline, G. C. Ashton and J. Kastelic, *Iowa State College.*

The effect of chilling time on the specific gravity of hog carcasses was studied. The relationship between specific gravity and measures of fatness was investigated on forty carcasses obtained from pigs approximately 200 lb. live weight. Measurements of specific gravity of the carcass, live probe, back fat thickness and percent lean cuts were made. Specific gravity was determined on the carcasses just before they were placed in the coolers and after 24, 48, and 72 hours of chilling. Back-fat thickness and percent lean cuts were determined after 72 hours of chilling. The specific readings for 0, 24, 48, and 72 hours of chilling were 0.9965, 1.0214, 1.0249, and 1.0276, respectively. The correlations between specific gravity and live probe, back-fat, and lean cuts were significant (P .05 or less) at all times of chilling. The correlations changed noticeably with time of chilling and were consistent in this respect for all three covariables except for sign. The correlations were maximal at 24 hours and then decreased to values at 72 hours approximating those at zero hours. This change in specific gravity points to the necessity of making specific gravity determinations at a uniform chilling time.

EFFECT OF REPEATED REFREEZING AND THAWING ON FRESH BEEF, PORK, AND LAMB. William E. Kramlich, *The Pennsylvania State University.*

Fresh beef, pork, and lamb were alternately thawed and refrozen five times at intervals of one week. Except for two one-pound samples of pork chops, the meat was packaged in the form of small roasts, each weighing from two to two and one-half pounds. The test samples were completely thawed in the unopened package at temperatures ranging from 64–70° F. After the thawing was completed, the package was opened and a bacterial count was made on the meat. The appearance and odor of the meat were noted throughout the test and after the sample had been thawed for the fifth time, slices of the meat were pan-broiled and tasted to determine the palatability. The initial 24-hour freezing period brought about a large decrease in the bacterial population of the meat. Relatively small increases in the bacterial counts were noted thereafter at each successive thawing but after five refreezing and thawing treatments, the number of bacteria present on each sample did not exceed 102,000 per gram and was considerably less for a number of the samples. The meat was found to be palatable and there was no undesirable odor or visible evidence of spoilage even after five refreezing and thawing treatments.

THE EFFECT OF PROTEIN LEVEL, PROTEIN QUALITY AND CHLORTETRACYCLINE (AUREOMYCIN) UPON GROWTH, FEED EFFICIENCY AND CARCASS COMPOSITION OF SWINE. D. H. Kropf, P. K. Lewis, Jr., R. H. Grummer, R. W. Bray and P. H. Phillips, *University of Wisconsin.*

Sixty-four weanling pigs were divided into 8 lots and fed the following rations: Lot I, 12 percent low quality protein (peanut meal); Lot II, Same as I + 9 mg. chlortetracycline per lb. of feed; Lot III, 16 percent low quality protein; Lot IV, Same as III + aureomycin; Lot V, 12 percent good quality protein; Lot VI, Same

as V + aureomycin; Lot VII, 16 percent good quality protein. Lot VIII, Same as VII + aureomycin. Protein levels were reduced during the feeding period when lots averaged 70 and 125 lb. The low protein ration was reduced to 11 percent and 10 percent, while the high protein ration was lowered to 14 percent and 12 percent. Average daily gains were 0.76, 0.88, 1.19, 1.15, 1.16, 1.36, 1.42 and 1.55 lb., respectively for Lots I through VIII, while feed per 100 lb. of gain was 503, 431, 379, 384, 393, 357, 335 and 332 lb. No treatment differences were observed in dressing percentage, viscera wt., kidney wt., leaf fat wt.; percentage yield of picnic shoulder, loin or total lean cuts; percentage of boned ham, percentage of total fat cuts, carcass length or eye muscle area at the 10th and 13th ribs. However, liver wt. tended to increase with an increase in feed protein level. Animals in Lots I and II differed significantly from those of the other lots in the following characters: percentage yield of Boston butt and picnic shoulder (greater); percentage fat back and clear plate (less) and thickness of fat back (less).

CARCASS COMPOSITION OF STEERS AND BULLS WITH AND WITHOUT STILBESTROL ADMINISTRATION DURING THE FATTENING PERIOD. L. E. Kunkle, Earle W. Klosterman and V. R. Cahill, *Ohio State University*.

This report concerns the carcasses of 103 Hereford cattle which received treatment as follows: control, 31 steers and 10 bulls; subcutaneous implantation of stilbestrol pellets, 31 steers and 10 bulls; oral administration of stilbestrol, 21 steers. Ten of the implanted steers and the ten implanted bulls received 84 mg. stilbestrol at the beginning of the 184-day feeding period and again at the midpoint. The other 21 steers received one 60 mg. implantation 120 days prior to slaughter. Oral administration consisted of feeding the hormone at the rate of 10 mg. per head daily. These cattle were marketed at approximately 15–18 months of age. Carcass measurements support the observation of raised tailheads resulting from implantation but alteration of carcass grade as a result of stilbestrol administration was not of statistical significance. A study of steer wholesale cut weights indicates a higher percentage in the five more desirable regions and a lower percentage in the five less valuable cuts. Implantation of bulls tended to enhance fat deposition and raise the carcass grade as compared with untreated bulls. An analysis of representative right sides for edible portion, fat and bone was made. Edible portion ranged from 69.88 percent of the control steer carcasses to 76.07 percent of the control bull carcasses. A highly significant correlation was found between the percent of edible portion and area of longissimus dorsi muscle taken in cross-section between the 12 and 13 ribs. Organoleptic tests for tenderness were performed and the data indicate that stilbestrol has little effect on tenderness.

THE SPECIFIC GRAVITY OF CERTAIN UNTRIMMED CUTS AS RELATED TO PORK CARCASS EVALUATION. Pearson, A. M., L. J. Bratzler, R. J. Deans, J. F. Price, J. A. Hoefer, E. P. Reineke and R. W. Luecke, *Michigan State University*.

In order to explore the possibility of using the specific gravity of certain untrimmed cuts, i.e., the shoulder, ham and loin, as a measure of carcass cut-out, data were collected on 103 hogs slaughtered in the University abbattoir. Specific gravity was determined for the entire carcass, for both hams, both shoulders, and both loins. In addition, carcass cut-outs and certain physical measurements were taken, and correlations were calculated to determine their relationship to specific gravity. The correlations between specific gravity of the entire carcass and specific gravity of the untrimmed cuts from the left side were all highly significant, being +0.93 for the ham, +0.91 for the loin, and +0.87 for the shoulder. Correlations were positive and highly significant between specific gravity for each of the three

untrimmed cuts from the left side with percent lean cuts minus fat cuts, length of carcass, percent lean cuts and percent primal cuts on both the live and carcass basis. Correlations for the same cuts were negative and highly significant between specific gravity and backfat thickness, percent fat trim and live probe. The specific gravity of the untrimmed ham gave a higher correlation with the percentage cut-outs than that of the other untrimmed cuts. Thus results indicate that the specific gravity of the untrimmed ham may be useful in predicting carcass cut-out.

FURTHER STUDIES OF THE INFLUENCE OF LIMITED-FEEDING BY THE USE OF HIGH FIBER RATIONS, UPON GROWTH, FATTENING AND CARCASS CHARACTERISTICS OF SWINE. R. A. Merkel, D. H. Traeder, R. W. Bray, R. H. Grummer, P. H. Phillips, and G. Bohstedt, *University of Wisconsin.*

Fiber levels of 12 and 16 percent were employed to restrict the feed intake of swine in dry lot. A basal ration was diluted with corn cobs, alfalfa hay or a mixture of corn cobs and alfalfa hay to obtain both medium and high levels for each of the sources of fiber. A control lot was hand-fed approximately 70 percent of the basal lot. Eight weanling pigs of mixed breeding were randomly assigned to each of eight lots and fed to a slaughter weight of 210 lb. A highly significant increase in the length of the feeding period was found between the treatments. The average daily gain and the dressing percent were highly significantly decreased by the medium (12 percent) and high (16 percent) fiber levels. The cost per cwt. of gain is least for the hand-fed lot and the lots restricted with alfalfa hay. The corn cobs produced the most costly gains and the mixture of corn cobs and alfalfa hay was intermediate. The carcass fat back measurement was significant between the lots and the carcass grade was highly significant. The carcass grades were superior in the lots restricted with 12 percent fiber as compared to the 16 percent level. No significant differences were observed for the yield of lean cuts either totally or separately as well as for carcass length. The area of the loin (eye muscle) approached significance at the 5 percent level. A significant increase in percentage of viscera (plus contents) was obtained on the restricted lots but no difference was found for the empty viscera. A significant and highly significant difference between the lots for the percentage of leaf and liver, respectively, was observed.

A COMPARISON OF FEEDING METHODS AS THEY AFFECT VEAL PRODUCTION AND CARCASS QUALITY. R. P. Niedermeier, N. N. Allen, Flora Hanning and R. W. Bray, *University of Wisconsin.*

Male Holstein and Brown Swiss calves were started on experiment after being with their dams 3 days and were slaughtered when 6 weeks old. Liberal whole milk feeding with and without iron supplement was compared to limited whole milk-hay-starter and to liberal milk replacer-hay-starter feeding. All calves were fed 30 mg. chlortetracycline daily. Milk replacer calves received 25,000 I.U. of vitamin A in addition. To date, 61 calves have been slaughtered. Liberal whole milk calves have made an average daily gain of 2.44 lb., while the milk replacer calves have averaged 1.38 lb. daily. Carcass grades ranged from top Choice for liberal whole milk calves to top Utility for milk replacer calves. The color of the meat was influenced by iron and copper supplement and by hay and grain feeding. The myoglobin content of the loin eye muscle varied from 0.33 mg. per gm. in the whole milk calves to 0.67 mg. in the calves fed whole milk supplement with iron and copper. Cooking and taste panel tests results are being analyzed.

SOME EFFECTS OF DIFFERENT LEVELS OF PROTEIN AND FIBER, AND ANTIBIOTIC SUPPLEMENTATION ON GROWTH AND CARCASS CHARACTERISTICS OF SWINE. J. W. Stevenson, R. L. Hiner and N. R. Ellis *U. S. Department of Agriculture.*

Winter and summer trials have been completed in which comparisons were made between two levels of protein (14 percent vs. 16 percent with subsequent reduction at fixed intervals); two levels of dehydrated alfalfa meal (4 percent vs. 16 percent introduced at 125 lb. average wt. of test animals); and presence or absence of Aureomycin (chlortetracycline)-vitamin B_{12} supplement. In each trial 48 crossbred weanling pigs were randomized to 8 treatments (2^3 factorial design) from litter outcome groups. Pigs were group fed ad libitum on concrete and were individually removed for slaughter at from 215–235 lb. live wt. Aureomycin-vitamin B_{12} supplementation significantly increased growth rate during the first 8 weeks on feed in both winter and summer trials but not for the latter half of either trial. Supplemented animals had higher dressing percentages, shorter legs, and plumper hams in the winter trial but did not differ significantly from unsupplemented pigs in the summer trial. In the winter trial high fiber (16 percent alfalfa) diets significantly reduced growth rate, dressing percentage, thickness of back fat and width through shoulders, but in the summer trial only width through shoulders was significantly reduced. Pigs which received the higher protein diets had significantly longer legs, less plump hams, and deeper loins in the winter trial, while all fat measurements, except wt. of leaf fat, were significantly reduced in the summer trial. Hams from pigs which had received high protein diets contained more lean in proportion to separable fat. Chemical analyses showed significantly higher content of water and protein and significantly less fat.

CARCASS STUDIES OF STEERS RECEIVING RATIONS WITH OR WITHOUT STILBESTROL WHEN FED EQUAL TOTAL CONCENTRATES AND/OR TO EQUAL LIVE WEIGHTS. J. R. Stouffer, Sleeter Bull, B. C. Briedenstein, A. L. Neumann and W. W. Albert, *University of Illinois.*

Twenty-one choice heavy yearling Hereford steers were divided into three lots and full-fed a fattening ration for from 96 to 125 days. Two lots received stilbestrol at the rate of 10 mg. per head per day while the other lot served as a control. The steers in one of the treated lots were fed until they attained an average weight of 1100 lb. and then slaughtered. The steers in the control lot were slaughtered after they had reached the same average weight, while the steers in the second stilbestrol lot were fed until they had consumed the same total amount of concentrates as the control lot. The cattle were trucked approximately 120 miles and delivered to a local stockyard where they remained 30 hours with free access to prairie hay and water which treatment ended 6 hours prior to slaughter. Data were collected to study the following: drift, cooler shrink, dressing percentage, on-foot grades, U.S.D.A. carcass grade, and cut out value of wholesale cuts. The wholesale rib was analyzed for the following: specific gravity, percentage of lean, fat and bone determined by physical separation, and complete chemical analysis of the edible meat. The area of the rib eye was measured with a planimeter at a point perpendicular to the backline at the base of the twelfth rib. Measurements of color of lean and of fat were made from steaks cut from the area of the thirteenth rib by the use of a recording spectrophotometer. Specific gravity and ether extract of the rib eye were also obtained. Samples of cod, honeycomb tripe, liver, kidney, lean from the rib and fat from the rib were taken in order to be assayed for residual stilbestrol.

A METHOD OF DETERMINING THE COMPOSITION OF SWINE CARCASSES; AND THE EFFECTS OF CHLORTETRACYCLINE (AUREOMYCIN) FEEDING ON SWINE CARCASS QUALITY. F. C. Wingert, W. J. Aunan, E. F. Ferrin, and L. E. Hanson, *University of Minnesota.*

Twenty-nine pairs of weanling pigs, from 3 breeds, were divided into 2 lots; a basal, fed a mixed diet containing 14–11 percent protein, and a treated fed the basal plus chlortetracycline at 10 gm. per ton. The lots were group fed to an individual final live weight of approximately 210 lb. After slaughter and chilling, average backfat thickness, carcass length, ratio of fat to lean from a tissue core, and dressing percentage were determined. Loin and ham muscle sections of the 29 pairs, and boned half-carcasses of 6 pairs were ground and sampled for chemical determination of moisture, protein, ash, and fat. Thiamine and riboflavin determinations also were made on the half-carcass, loin, and ham samples to determine if the antibiotic would affect the deposition of these vitamins in the meat. The treated group did not differ significantly from the control in average backfat thickness, carcass length, ratio of fat to lean in the tissue core, or dressing percentage; nor in proximate chemical composition, thiamine content, or riboflavin content of the loin muscle sections, ham muscle sections, or of the carcasses. The time required to reach final weight was highly significantly decreased (P less than 0.01) by the treatment. Correlations between the proximate chemical composition of the loin, or ham muscle sections and the carcasses were small and insignificant. The same correlations for thiamine content however, on a dry fat-free basis, were highly significant. Only the loin muscle sections and the carcasses were significantly correlated (P less than 0.05) for riboflavin.

Pasture and Forages Section

R. J. Webb, *Chairman*

COMPOSITION AND PALATABILITY OF STACKED LEGUME-GRASS SILAGES. R. S. Allen, A. R. Porter and N. L. Jacobson, *Iowa State College.*

Approximately 500 tons of chopped, non-wilted forage (about 50 percent alfalfa and 50 percent grasses; mean moisture content, 77.9 percent) were ensiled in a stack on a concrete slab (24 x 100 ft.). Sodium metabisulfite (6 lb. per ton) was added at the field harvester to half of the forage (12 x 100 ft. section of the stack). Samples of silage were taken for analysis at three heights from each of four areas of each half of the stack. No marked differences between treatments were apparent, but silage with metabisulfite contained somewhat less butyric acid and slightly more lactic acid than the non-preserved silage. Means (percentage of dry matter), when values for the two treatments were combined, at 18, 36 and 52 inches above the bottom of the stack were, respectively: crude protein, 22.9, 15.2, 12.6; ammonia nitrogen, 1.30, 0.83, 0.50; total acidity, 11.9, 7.7, 3.9; lactic acid, 0.08, 0.05, 0.05; and butyric acid, 2.43, 2.51, 1.85. Carotene levels (mcg. per gm. DM) were 344, 155 and 183, and the pH values were 5.58, 5.28 and 5.03. There were no significant differences in preference of either type of silage by dry cows. The feeding systems employed included: silages, silages plus concentrates, silage plus chopped hay, and silages plus concentrates plus chopped hay. The addition of butyric acid (1 lb. per 100 lb. of silage) had no appreciable effect on palatability of the stack silage.

DAILY LOW LEVEL PHENOTHIAZINE CONSUMPTION BY RUMINANTS AS AFFECTED BY FORM OF ADMINISTRATION AND OTHER FACTORS. D. M. Baird, *Georgia Experiment Station.*

An attempt has been made to find an easier and more practical method for a satisfactory daily low level phenothiazine(pheno) administration than the present recommended salt-pheno mix. A flavored mineral-pheno block has been developed that gives fairly satisfactory intakes for cattle but not for sheep. The daily consumption of pheno by grazing sheep in one test according to treatment was as follows: Lot I, 1 pt. Pheno-9 pt. Salt, 1.10 gm.; Lot II, 1 pt. Pheno-9 pt. 1:1:1 Mineral mix, .55 gm.; Lot III, 0.5 pt. Flavored-Pheno-9.5 pt. mineral mix, .30 gm.; Lot IV, Flavored 1:1:1 Mineral Block containing 7.5 percent Pheno., .39 gm.; Lot V, Flavored 70 percent salt and mineral block containing 7.5 percent Pheno., .39 gm. Grazing cattle on winter small grain pastures have consumed the following: Lot I, 1:12 Pheno-mineral mix 2.15 gm.; Lot II, 70 percent above block .53 gm.; Lot III, 1:1:1 above block 1.23 gm. Various other consumption tests have shown the form of administration to be an important factor in daily consumption as well as the level of animal nutrition, drylot or pasture feeding, type of pasture, stage of pasture growth and lushness, or pasture and animal individuality including size and age. Fecal egg counts have been found to not always give a reliable indication of treatment effect or of adult worm numbers found at postmortem. A more positive indication of treatment is postmortem worm counts or recovery of pre-parasitic larvae from the forages being grazed. The low level intake of less than the 0.5 gm. daily does not appear to be effective in controlling parasitic contamination of pastures and subsequent pickup of larvae by grazing animals. A daily intake of 1–2 gm. apparently is satisfactory.

A STUDY OF SPRING LAMB PASTURE GAINS TO WEANING. L. H. Blakeslee, M. B. Tesar and R. E. Morrow, *Michigan State University.*

A study of the average daily gains by two week intervals of 225 lambs on legume and grass pasture mixtures in 1952, 1953, and 1954 showed early gains of .7 to .85 with .17 to .26 at weaning. The dams were western ewes and sires Suffolk, Columbia, and Corriedale. The lambs were born during the last of March or after. The ewes and lambs were turned to pasture about the middle of May each year. The results of analyses of variance on the average daily gains for the two week intervals showed that the downward consecutive differences were significant for most growth study periods. The 1952 Suffolk sired lambs average daily gain to weaning was .468 lb. The 1954 Columbia and Corriedale sired lambs average daily gain was .452 and .450 lb., respectively. The 1953 Suffolk and Columbia sired lambs average daily gain to weaning on pasture was .434 and .378 lb., respectively. Analyses of covarience showed a significant difference between growth of 1953 Suffolk and Columbia sired lambs as well as between the 1954 Columbia and Corriedale sired lambs. All lambs showed a significant correlation between birth weight and weaning weight. The Suffolk sired lambs showed a significant correlation of the weaning weight to the weight of the dam at weaning.

RANGE BEEF CATTLE NUTRITION TECHNIQUES. Verle R. Bohman, Henry Melendy and Marven A. Wade, *University of Nevada.*

Range beef cattle nutrition research has lagged behind other nutritional research because of a lack of suitable methods. Methods applicable to feed lot or improved pasture studies are not applicable to range nutrition research. Harris *et al.* (J. An. Sci. 11:181, 1952) has described techniques that are applicable to nutrition studies of range sheep. However, range beef cattle are not gregarious like sheep,

and the cost of fencing a sufficient number of pastures to adequately measure the results is economically prohibitive. Techniques have been developed by the authors that are applicable to detailed range beef cattle nutrition research. Portable corrals and feeding chutes have been devised that can be readily moved to new areas as the range is utilized. Water is hauled to the experimental area and this serves to keep the animals grazing around the temporary headquarters. Animals are identified by ear tags and a black hair band on the side of the animal. Animals enter a feed chute at random and are individually fed a supplement that was previously weighed and identified. Seventy-five head of experimental beef cattle can be fed in this manner in less than two hours. Animals are fed every other day. A combination squeeze chute and scale are mounted on a trailer for obtaining periodical weights and to restrict the animals for obtaining blood samples. Preliminary data using these methods indicate that beef cattle on a semi-desert winter range respond readily to supplements of energy, phosphorus and protein. Blood data indicates that total cell, hemoglobin, vitamin A, carotene and calcium was normal, although the level of blood phosphorus was low.

SELF-CONTAINING CELLULOSE DIGESTERS OF COMMON RUMINANT FEEDS. J. L. Cason, R. D. Mochrie and W. E. Thomas, *North Carolina State College.*

Aqueous extracts of concentrates, fresh forages and hays were prepared in a Waring blender, filtered through cheese cloth and centrifuged. The supernatant liquid was used as the source of cellulolytic activity. The activity was measured by the time required to reach 50 percent hydrolysis of a soluble cellulose solution (CMC-70M) in Ostwald-Fenske viscometer tubes. Samples of the same feed varied considerably with more variation noted in the fresh forages than in the other two classes. Citrus pulp and soybean meal exhibited very low activity; cottonseed meal had slight activity; cracked corn, ground snapped corn and barley had appreciable activity. Within the fresh forages, blue grass, fescue, and Bermuda were more active than alfalfa, lespedeza or Sudan grass. Soybean, orchard grass, and alfalfa hay all showed appreciable activity. The cellulolytic activity in natural feeds compared to that of bovine rumen contents indicates that the activity associated with the feeds could contribute appreciably to the total cellulolytic activity in the rumen.

THE INFLUENCE OF FERTILITY TREATMENTS AND METHODS OF RENOVATION UPON THE GRAZING VALUE OF LEGUME AND GRASS PASTURES. G. F. Cmarik, G. E. McKibben and H. A. Cate, *University of Illinois.*

Six ten-acre fields were seeded to a basic mixture of Ladino, timothy, redtop, alfalfa, and lespedeza. In addition each field had a different grass. All fields were treated with limestone, superphosphate, and rock phosphate prior to seeding. A fertility maintenance study included rock phosphate compared to superphosphate on an equal P_2O_5 basis, alone and with potash. Highest 7 year average forage yields came from rock phosphate and potash. The yield of forage and animal gains followed a typical pattern. Yields in pounds of D.M. per acre varied from 3970–4521 in the year of establishment to 10191–12983 for the fourth year. Animal gains in pounds per acre for the corresponding years were 26–88 and 373–476. The results in the fifth year resembled the first year. When one-half of each of the fields was renovated in the seventh year by seeding sudan grass, it produced an average of 2339 lb. of D.M. and 89 lb. of animal gain. This compared to 6584 lb. of D.M. and 284 lb. of animal gain produced on the other one-half of the field from which the legumes had disappeared, but which had been nitrated. This occurred during

a very dry year and indicates the fallacy of complete dependence on sudan grass. New legume seedings made without a nurse crop produced 4 times the gain with twice the carrying capacity of seven year old grass stands through mid-June. An average of 20 lb. D.M. was required to produce a pound of gain on legume pasture versus 34 lb. on grass. These results indicate the need for pastures containing grass-legume mixtures or pure stand seedings harvested at the proper time.

FURTHER EXPERIMENTS WITH SODIUM METABISULFITE AS A PRESERVATIVE FOR GRASS SILAGE. R. L. Cowan, E. Keck, Jr., J. W. Bratzler and R. W. Swift, *Pennsylvania State University*.

Two experiments have been conducted to show (A) the relative merits of 3 methods of ensiling alfalfa at 3 stages of maturity and (B) the effect of increasing levels of bisulfite on its effectiveness as a preservative, and on the palatability of the silages. (A) First cutting alfalfa was ensiled at prebloom, early bloom and full bloom in 9 experimental silos (4 × 8 ft. steel), one silo at each stage of maturity receiving each of the following treatments: (1) 8 lb. bisulfite per ton, (2) unwilted, no preservative, and (3) wilted, no preservative. Losses of nutrients from each silo due to fermentation, seepage, and spoilage, were measured by total balance, and digestion trials were run with sheep on all silages. At the prebloom stage, treatment with bisulfite resulted in recovery of 64.6 lb. of *digestible* dry matter for each 100 lb. of dry matter of ensiled forage, as compared with 43.9 lb. and 48.4 lb. for the no-preservative and wilting treatments, respectively. At the early bloom stage the values for the same respective treatments were 50.6 lb., 44.7 lb., and 50.9 lb. At the full bloom stage, recoveries were 44.6 lb. for the bisulfite silage, and 39.5 lb. for the untreated, while excessive top spoilage in the wilted silage resulted in recovery of only 28.9 lb. of digestible dry matter per 100 lb. of dry matter ensiled. (B) In the second experiment unwilted first cutting alfalfa was ensiled at early bloom in 5 silos (5 × 20 ft. wood) with 0, 5, 8, 12, and 16–20 lb. of bisulfite per ton. Values for digestible dry matter recovered in the silages for the respective treatments were as follows: 41.6 lb., 48.8 lb., 50.5 lb., 46.3 lb. and 51.6 lb. per 100 lb. of forage dry matter ensiled. Palatability, as measured with 22 yearling dairy heifers, was not reduced, except very slightly at the highest (20 lb.) rate of bisulfite application.

AN APPARENT INFLUENCE OF LADINO CLOVER AND BIRDSFOOT TREFOIL PASTURE ON THE PROMPTNESS OF CONCEPTION IN EWES. P. H. Engle, D. S. Bell, O. G. Bentley, A. L. Moxon, R. R. Davis and W. D. Pounden, *Ohio Agricultural Experiment Station*.

It has been suspected for some years that the conception rate among ewes is affected by certain kinds of pasture on which ewes graze prior to and during the breeding season. In 1953, three lots of 21 ewes each were placed, respectively, on three differing pastures: (1) native bluegrass, (2) Ladino clover, and (3) birdsfoot trefoil. In 1954, 7 aged ewes were dropped and 14 additional yearling ewes were added to each lot and the test repeated. The breeding season each year was bracketed into six successive 17-day heat periods, starting with Sept. 12 and Sept. 13, respectively. Considering it desirable that ewes settle within 5 weeks of starting the ram, it is significant that 61.9 percent in 1953 and 76.9 percent in 1954 of the ewes on bluegrass pasture lambed to first or second period service, whereas the percentage lambing in the Ladino pasture lot was 33.3 and 33.3 and in the trefoil pasture lot, was 28.6 and 30.8 in the same period for each year. It seems significant, also, that whereas only 4.8 and 3.8 percent from the bluegrass lot conceived to service in the 4th or 5th breeding period each year, 23.8 and 22.2 percent of the Ladino clover lot, and 42.8 and 30.8 percent of the trefoil lot in

each year lambed to service in the 4th or 5th period. The two legume pasture lots of ewes apparently were under some pasture influence that slowed the rate of conception at the outset and left many ewes for late season breeding.

THE INTAKE AND DIGESTIBILITY OF NUTRIENTS IN THE TOP AND BOTTOM PORTIONS OF THE ALFALFA PLANT. W. A. Hardison, W. N. Linkous, C. Y. Ward, R. E. Blaser, R. W. Engel and G. C. Graf, *Virginia Agricultural Experiment Station.*

Eight dairy heifers weighing from 350 to 570 lb. were used to study the intake and digestibility of nutrients in the top and bottom portions of pre-bloom alfalfa. The forage was fed fresh daily in amounts which were readily consumed by the animals. A partial switchback design was employed and total collections of feces were made over 7-day periods. The chemical composition (percent) of the top and bottom portions of the alfalfa, respectively, was as follows: D.M., 19.0—19.6; C.P., 26.0—17.2; E.E., 2.5—2.0; C.F., 17.5—26.2; N.F.E, 4.36—4.46; Ash, 10.4—10.1. The average coefficients of apparent digestibility and TDN content of the two portions were as follows: D.M., 73.6—64.5; O.M., 75.2—65.5; C.P., 83.3—75.6; E.E., 11.8—32.0; C.F., 65.3—61.4; N.F.E., 78.1—65.6; T.D.N., 67.8—59.7. The top portion of the alfalfa supplied the animals with a higher average daily intake of digestible D.M., digestible O.M., digestible C.P. and digestible N.F.E. and a lower daily intake of digestible E.E. and digestible C.F. than did the bottom portion. The forage (both top and bottom) decreased in percent protein and increased in percent crude fiber from trial 1 to trial 2. Likewise, the digestibility of the forage decreased from trial 1 to trial 2. Data will be presented on the use of Cr_2O_3 and plant pigments for estimating digestibility.

EFFECT OF LIGNIFICATION IN PLANTS ON DIGESTION OF THE PLANT CELLULOSE *IN VITRO*. L. D. Kamstra, A. L. Moxon and O. G. Bentley, *Ohio Agricultural Experiment Station.*

The effect of stage of maturity upon plant cellulose digestion by rumen microorganisms *in vitro* has been studied. Alfalfa, timothy and orchard grass were harvested at three stages of maturity, air dried, and ground to 40 mesh. Cellulose-containing fractions (Crampton and Maynard cellulose, A.O.A.C. crude fiber, Wilcox and Moxon fiber, and holocellulose) were isolated from these samples. The rate of cellulose digestion was determined by the artificial rumen technique for both the cellulose-containing fractions and the whole plant materials. As much as 50 percent decrease in the rate of cellulose digestion was observed between the first to the third sampling of orchard grass and approximately a 30 percent decrease with comparable samples of timothy and alfalfa. Isolated cellulose from these same samples showed less variation in the rate of cellulose digestion. The digestion of the isolated cellulose proceeded at a more rapid rate than the whole plant cellulose, especially the cellulose in the most mature samples. The results obtained thus far indicate that lignification is an important factor in depressing the rate of digestion of cellulose in mature plants. The digestibility comparison of various isolated fractions will also be discussed.

EARLY VS. DELAYED GRAZING OF ALFALFA FOR MILK PRODUCTION. R. H. Lush, A. G. Van Horn and M. W. Whitaker, *University of Tennessee and U.S.D.A.*

Five years (1950–54) results at Lewisburg indicate alfalfa seeded with orchard grass and Ladino clover may be satisfactorily maintained under rotational grazing with a 20-day interval for growth recovery, by either delayed (first cutting for

silage) or all-season grazing. Moderate grazing with Jersey cows fed limited concentrates on replicated areas uniformly seeded, fertilized and mowed was practiced from April 1 to October 31, excepting in periods of extreme drouth in the late summers of 1951–54. Rainfall averaged 6.1 inches below normal for the four years. The plots grazed all-season produced an average of 123 standard cow days and 5330 lb. of milk per acre and the comparative plots on which grazing was delayed until June, a cutting of 2885 lb. of hay or 8425 lb. silage plus 75 standard cow days and 3530 lb. of milk per acre. While the all-season grazing produced 17 percent greater net value than delayed grazing, the latter system produced more estimated T.D.N. with better seasonal distribution and maintained a superior stand of alfalfa through the fifth year. Chemical analysis of vegetation in June and October showed rather high protein and low lignin regardless of season or method of grazing. Samples cut in mid-June averaged 26.2 percent crude protein and 7.7 percent lignin, dry matter basis. The cows obtained an average of 62 percent of their total nutrient requirements from grazing. No serious difficulty with bloat was encountered but there was little clover and more orchard grass present after the first season.

GROWTH RESPONSE OF YOUNG DAIRY CALVES ON PASTURES. M. E. McCullough, *Georgia Experiment Station.*

Over a three-year period, 7-day old Guernsey and Jersey calves were allowed free access to pasture and hay was omitted from the ration. Milk was fed to 6 weeks and grain limited to 4 lb. per day. Dry matter digestibilities, weight gains and blood analysis were used as response criteria. Weight gains were affected by forage quality. Calves on excellent forage averaged 152 lb. at 12 weeks, those on good forage 153 lb. and those on poor forage 114 lb. The feeding of hay on pasture would probably improve gains on all types of forage. Blood levels of glucose, hemoglobin, calcium, phosphorus and serum protein followed normal trends and were apparently not affected by forage quality. A limited number of calves were limited to pasture alone after milk was discontinued. Although the calves were digesting forage dry matter as well as older animals at 10 weeks of age, intake was apparently insufficient to permit normal growth before the calves were 12–14 weeks of age. The pasture reared calves developed greater depth of body and capacity than similar calves reared in the barn.

THE ARTIFICIAL RUMEN AS A PROCEDURE FOR EVALUATING FORAGE QUALITY. W. J. Pigden and J. M. Bell, *University of Saskatchewan.*

One gram samples of 11 forages which were ground to pass a 2.0 mm. screen were fermented for 48 hr. in 50 ml. Erlenmeyer flasks each containing 12.5 ml. of fresh rumen inoculum (sheep), 3.7 ml. of buffer-mineral solution, 0.5 gm. calcium carbonate, and 8.8 ml. distilled water. The fermentation residues were oven dried, hydrolized with 72 percent sulfuric acid and analyzed for total anthrone carbohydrate. The regression of percent organic matter digested (Y) by sheep on percent anthrone carbohydrate fermented in vitro (X) was: Y equals 10.61 plus 0.90 X. (P. less than 0.01.) Se equals 2.76 percent. Two other regression equations for supplementing the microbiological procedure were calculated from the chemical composition of these forages. The first gave an excellent estimate of DCP (Y) from their crude protein (X) content. The regression equation was: Y equals —3.79 plus 1.00 X. (P less than 0.01.) Se equals 0.39 percent. The second related digestible ether extract (Y) to forage ether extract (X) and the equation was: Y equals —1.29 plus 0.90 X. (P less than 0.01.) Se equals 0.18 percent. Percent organic matter digested in vitro was converted to TDN as follows: TDN equals (percent

organic matter digested in vitro) times (percent organic matter in forage) divided by 100 plus (digestible ether extract gm. per 100 gm. dry matter) times 1.25. The artificial rumen procedure, when used in conjunction with these equations, gave estimates of TDN and DCP for 11 forages which were in close agreement with those derived conventionally with sheep.

OAT SILAGE STUDIES WITH BEEF CATTLE. D. L. Staheli, W. W. Albert, E. G. Adams and A. L. Neumann, *University of Illinois.*

One of the greatest deterents to the expanded use of crop rotations which include legumes is the low income produced by the oat nurse crop. In these investigations this crop was harvested when in the soft dough stage, as silage, and fed to beef cattle in various feeding programs. A 133-day wintering trial with calves indicated that oat silage plus 3.5 lb. of corn was about equal to legume-grass silage plus 3.5 lb. of corn, the gains being 1.74 and 1.80 lb. per day respectively with the difference not being statistically significant. Both silages, made without preservatives, were readily consumed and in neither case was a protein supplement fed since the silages contained 10.44 and 14.29 percent protein respectively on a dry matter basis. Utilized in the above manner the oats returned over five times as much net income as when harvested for grain even though the yield of 5.1 tons per acre was low when compared with a 3-year-average yield of 9.0 tons. Using yearling steers in a second trial, oat silage was compared with legume-grass silage in a combination limited and full-fed fattening program. In the 98-day limited-fed phase the ADG's were 2.21 and 2.07 lb. respectively in favor of the oat silage lot, but during the 102-day full-feeding phase, the gains were 1.94 and 2.45, indicating that energy is not the only limiting factor in oat silage. A third trial, which consisted of 3 lots of calves being wintered on oat silage plus 0, 2, and 4 lb. of corn respectively, was conducted to determine the most economical level of energy supplementation. The resulting average daily gains were 0.69, 0.87 and 1.27 lb. respectively, with the 1.27 lb. gain being significantly more economical.

FATTENING STEERS ON IRRIGATED PASTURE. O. O. Thomas and F. S. Willson, *Montana Agricultural Experiment Station.*

A five-year study, conducted during successive pasture seasons (1950–1954) with a total of 160 steers and 40 heifers, was designed to determine whether or not yearling steers or heifers self-fed concentrates can be fattened to slaughter grades on irrigated pastures and to determine if such a practice were profitable. The pasture used in these trials was a 15.5 acre plot seeded to the Huntley grass mixture. Steers were weighed at 28-day intervals during the grazing season. In 1950 and 1951, all steers were self-fed concentrates (two-thirds dry rolled barley and one-third dried molasses beet pulp). In 1952 and 1953, one group of steers was self-fed concentrates and one group of steers received only grass. In 1954, heifers were used and were divided into four groups; one group received only grass and the other three groups were self-fed concentrates, beginning at different dates during the season. Steers weighing approximately 550 lb. at the start of the grazing season reached a slaughter grade of Good to Choice. When steers or heifers were self-fed concentrates all season, the beef produced per acre ranged from 705 to 1204 lb. per acre; the average daily gain was 2.5 lb. per day for steers and 2.2 lb. per day for heifers; the average daily grain consumption was about 13 lb.; and an average of about 500 lb. of grain was required per hundred pounds of gain. The average daily gain of steers receiving only grass was about 1.7 lb. One year's trial with heifers indicated that it was more profitable to feed concentrates the entire season rather than during only part of the season.

THE VALUE OF ALTA FESCUE PASTURE FOR WINTERING PREGNANT EWES. G. B. Thompson, A. J. Dyer and P. Q. Guyer, *University of Missouri.*

The nutritional adequacy of Alta fescue pasture for wintering mature pregnant ewes was studied in two tests. Large type ewes were in the first test and large and small type in the second. Fescue pasture was the sole ration for one group (Lot one); another group (Lot two) received in addition to pasture, a liberal allowance of concentrates during the last 60 days of gestation. The ewe gains and/or losses, lamb birth weights and subsequent performance, milk yields secured over a 24-hour period during each of the first 9 weeks of lactation, and wool yields were the criteria for measuring the adequacy of the rations. Lot 2 ewes gained more during pregnancy, bore heavier lambs, and produced more milk and wool. However, the differences were not great enough to compensate for the additional feed required. The performance of the lambs, subsequently fattened for market, substantiate this statement. The results secured indicate that under the conditions for these tests Alta fescue pasture was adequate for wintering pregnant ewes.

THE EFFICACY OF THE PLASTIC LABORATORY SILO IN STUDYING GRASS SILAGE. B. J. Walker, D. L. Hill and N. S. Lundquist, *Purdue University.*

Experiments conducted during 1954 and 1955 have shown that grass-legume silages prepared in the plastic laboratory silo are comparable to similar silages made in conventional tower silos. Comparisons based on pH, color, odor and volatile fatty acid content incidate that a typical silage fermentation occurs. Silages were stored for 12 months without mold growth. In recent experiments 1–2 lb. of fresh forage in each silo appeared to be adequate. Three lots of chopped alfalfa were ensiled 30, 60 and 90 minutes after cutting to determine if time from cutting to ensiling had an effect on acid development. Cerelose was added to all lots at the rate of 40 lb. per ton. After 21 days identical pH values of 3.90 were observed for all three silages. Thus, the worker would have time to apply other treatments which may be needed in his studies. Additives must be mixed uniformly in order to prevent large sampling errors. Carefully prepared duplicates should vary less than 0.1 pH unit. Observations to date indicate that acid formation as measured by pH is usually complete in 21 days at normal temperatures (70–85° F.). In addition to its use in studying silage fermentation the plastic laboratory silo may also serve as a screening device for new ensiling techniques.

INDICATOR EXCRETION CURVES BY SHEEP ON VARIOUS FORAGES. Patch G. Woolfolk, R. B. Grainger, Thomas Herndon, Neil Bradley and W. C. Templeton, *University of Kentucky.*

During a 10-day preliminary and a 10-day collection period one 2-gm. capsule of Cr_2O_3 was administered at 8:00 a.m. daily to each of 5 lambs on a constant daily intake of Ky. 31 fescue. Fecal collections were taken at 8:00 a.m., 4:00 p.m., and 12:00 p.m., daily and analyzed separately. Average concentration of Cr_2O_3 per gram of air dry feces and standard deviations were 7.68 ± 2.13, 6.79 ± 1.39, 5.83 ± 1.55, 5.89 ± 2.34 and 5.86 ± 1.42 mg., respectively, for the five lambs. Average recovery of Cr_2O_3 was 100.3 percent. In a second trial in which groups of 3 lambs each were fed clipped bluegrass, bromegrass, or fescue and similar groups were allowed to graze these forages, fecal collections were taken six times daily. Average concentration of Cr_2O_3 in the feces ranged from 5.14 to 15.41 mg., per gram of air dry feces and standard deviations from 1.41 to 7.43 mg. Average concentration of chromogen ranged from 491 to 1164 units per gram of air dry feces and standard deviations from 54 to 261 units. There appeared to be no

definite pattern for either Cr_2O_3 or chromogen excretion. These rather large variations in excretion show need for further work if small individual fecal samples are to be relied upon in determining digestibility and intake of forages by indicator methods with grazing lambs.

Physiology Section

V. R. Smith, *Chairman*

DIETHYLSTILBESTROL AND OXYTETRACYCLINE (TERRAMYCIN) IN COMBINATION FOR GROWTH PROMOTION IN FEEDER CATTLE. C. R. Adams, W. M. Reynolds, W. C. Sherman and H. G. Luther, *Chas. Pfizer & Co., Inc.*

The effect of stilbestrol and oxytetracycline (Terramycin) alone and in combination upon gains, feed efficiency and carcass quality of steers was tested with high energy rations. In the first trial the basal comprised chopped alfalfa hay, ground yellow corn, whole oats, whole bran, linseed oil meal and soybean oil meal. Four groups, each of 20 steers averaging 743 lb., were supplemented as follows: none, oxytetracycline (TM) 10 gm. per ton, stilbestrol 10 mg. per day, and stilbestrol plus TM. Results in each group in order named were: average daily gains, 2.25, 2.47, 2.47 and 2.94 lb.; av. lb. feed per lb. gain, 11.3, 10.8, 9.8 and 9.1; av. carcass grade, 9.95, 9.55, 9.1 and 9.55. (Scale: 8 = medium good; 9 = high good; 10 = low choice.) In a second trial with four lots each of twelve 836 lb. steers, the basal ration consisted of corn and cob meal (70–30) free choice, with a concentrate fed at a rate of 2 lb. per day. Supplementation of the four groups was the same as in the first trial. Results for the unsupplemented, TM, stilbestrol, and stilbestrol plus TM groups in order named were: av. daily gains, 2.03, 2.38, 2.46 and 2.55 lb.; av. lb. feed per lb. gain, 12.61, 11.0, 10.57 and 10.16; av. carcass grades, 8.72, 9.0, 8.84 and 9.35.

THE EFFECT OF AGE AND PLANE OF NUTRITION ON GROWTH HORMONE CONTENT OF PITUITARY GLANDS OF HOLSTEIN HEIFERS. D. T. Armstrong and Wm. Hansel, *Cornell University*.

Pituitary glands were collected from 60 Holstein heifers fed on three planes of nutrition, and slaughtered at 16, 32, 48, 64, and 80 weeks of age. The anterior lobes were frozen, ground in a tissue homogenizer, extracted with 0.9 percent saline, and assayed for growth hormone content by the hypophysectomized rat tibia test. A purified growth hormone preparation (Armour) was used to prepare a standard growth-response curve. Significantly different ($P < .05$) concentrations of growth hormone were found at different ages, with means of 11.67, 10.90, 8.18, 6.98, and 7.73 mg. per gram of anterior pituitary at 16, 32, 48, 64, and 80 weeks of age, respectively. Differences between levels of nutrition were not significant. Correlations of 0.37 and 0.42 were obtained when these growth hormone values were compared with percentage increases in body weights and heights at withers during the sixteen weeks prior to slaughter. Using thyroid acinar cell height of injected rats as an indication of thyrotropic hormone activity of the pituitary extracts, significantly different ($P < .05$) mean cell heights of 8.12, 8.24, 7.94, 7.42, and 7.41 micra respectively were obtained at 16, 32, 48, 64, and 80 weeks of age. Correlations between acinar cell heights and percentage increase in body weights and heights at withers during the 16 weeks prior to

slaughter were 0.45 and 0.46, respectively. Differences in cell heights between levels of nutrition approached significance, mean cell heights of 7.61, 7.72, and 8.15 micra respectively being obtained for the low, medium, and high levels of nutrition.

EFFECT OF ENVIRONMENT ON GROWTH AND CARCASS QUALITY OF SWINE FED AN ANTIBIOTIC SUPPLEMENT AND/OR VIGOFAC. J. P. Bowland, *University of Alberta.*

Thirty-two 45 lb. weanling pigs, equalized as to sex, were allotted to 4 groups to study the effect of environment (new versus old barn) on the response of the pigs to a chlortetracycline (Aureomycin) supplement and/or Vigofac (Pfizer). All pigs were farrowed in a barn that had housed pigs for a number of years thus allowing exposure to any subclinical disease present. At an average age of 5 weeks the pigs were transferred to a new barn where they were held until allotment. The treatments which were replicated in the new and old barn were as follows: Lot 1, control-ration based on barley; Lot 2, control + 9 gm. antibiotic per ton; Lot 3, control + 3 lb. Vigofac per ton; Lot 4, control + 9 gm. antibiotic + 3 lb. Vigofac per ton of feed. Following six weeks on trial neither supplement gave a growth response in the new barn, while both supplements alone or in combination resulted in significantly higher ($P < 0.01$) rate of gain in the old barn due to a reduced gain in the control pigs. During this period rates of gain in lb. per pig per day from Lots 1 to 4, respectively were as follows: new barn, 1.23, 1.27, 1.15, 1.32; and old barn, 0.96, 1.29, 1.36, 1.43. To market weight a similar trend in gains was evident except that limited improvement from supplementing the ration became evident in the new barn. Carcass measurements indicated no definite quality differences.

GRADIENTS IN RUMEN, BLOOD, AND RECTAL TEMPERATURES. S. Brody, R. E. Stewart and H. E. Dale, *University of Missouri.*

Feeding a fasting cow increased first her rumen temperature (measured by thermocouple), followed by increase in rectal (body) temperature. Injecting antipyretics (which increase heat loss and, therefore, lower body temperature), on the other hand, lowered first the rectal (body) temperature, followed by increase in rumen temperature. These differences in time sequence of temperature change following feeding and antipyretic injection suggest that, by appropriate methods, this rumen heat production could be measured by difference between indirect calorimetry which does not include the rumen (99 percent of the rumen bacteria are obligate anaerobes) and direct calorimetry which includes the rumen heat. Following a 24-hour fast the mean temperatures of the rectum, lower, middle, and upper rumen of two dry Jersey cows were 100.3°, 101.0°, 101.6°, and 101.7° F., respectively; when normally fed the temperatures were 100.6°, 101.7°, 103.6°, and 104.0° F., respectively. Feeding thus greatly increased the rumen temperature but slightly the rectal temperature; watering sharply reduced the rumen temperature but slightly the rectal temperature. When the rectal temperature was 100.3° F. and the rumen temperature was 101.7°–104° F., the blood temperature, as here measured (thermocouple in tip of a 72-inch polyethylene catheter inserted into the right jugular vein), was 99.1° F. 6 to 18 inches deep, and 100.3° F. 24 to 36 inches deep. Environmental temperature rhythms contributed substantially to rectal and rumen diurnal temperature rhythms which were 1° F. higher during hot (70–100° F.) than cold (10–40° F.) weather.

THE EFFECT OF INTERMITTENT EXPOSURE TO HIGH AMBIENT TEMPERATURE ON THE PHYSIOLOGICAL RESPONSES OF DAIRY BULLS. R. B. Casady, J. E. Legates and R. M. Myers, *North Carolina State College.*

Young Holstein bulls were subjected to a temperature of 105° F. and humidity of approximately 34 mm Hg. for 6 hours per day for 5 consecutive days, in a climatic chamber. Between exposure periods the temperature was lowered to 60–65° F. After 5 daily exposures the bulls were maintained at 60–65° F. and 34 mm Hg. for 4 weeks and then exposed to 5 more days of 105° F. and 34 mm Hg. 6 hours per day. The bulls were subjected to four such weekly exposures with 4-week intervals. Rectal temperature, respiratory rate, rump skin temperature, lower leg skin temperature and scrotal skin temperature were recorded hourly during the high temperature periods and twice daily, at 0530 and 1730, during the four weeks when the temperature was maintained at 60–65° F. A control bull of similar age was maintained, in a separate chamber, at a temperature of 60–65° F. and 34 mm Hg. vapor pressure twenty-four hours per day throughout the entire experiment. The measurements noted above were obtained twice daily at 0530 and 1730, plus at 0800 and 1500 on the days the other bulls were subjected to heat stress. Semen collections from all three bulls were obtained weekly and examined for motility, concentration, abnormalities and the number of living and dead sperm, using a differential staining technique. Preliminary examination of the results indicates a cumulative, or carry-over, effect of stress as evidenced by a progressive increase in responses over the five day exposure period and with successive weeks of exposure. Spermatogenesis did not seem to be impaired, though rectal temperatures reached levels of 107.2° F. and 107.4° F., and scrotal temperatures reached 103.0° F. and 103.4° F. Tabulated results and statistical analyses will be presented and discussed.

BLOAT STUDIES WITH VARIOUS FORAGES, FORAGE EXTRACTS AND DRUGS *IN VIVO* AND *IN VITRO*. C. M. Derrickson, C. M. Thompson and R. B. Grainger, *Kentucky Agricultural Experiment Station.*

In August 1954, 8 cows of a 35-cow herd bloated while grazing a pure stand of Buffalo alfalfa. Five of 15 sheep that grazed the same forage also bloated. Fresh forage extracts (I) and a two-fold concentrate (II) of I from the bloat-producing alfalfa administered by a stomach tube have produced bloat in sheep. Various other fresh forage extracts have failed to produce bloat. *In vivo* studies show the bloat-producing factor(s) to be non-protein in nature, heat stable and water soluble. Bloat was also produced by the injection of histamine, but the administration of other drugs gave negative results. *In vitro* kymograph studies with isolated rabbit intestine show that motility is inhibited by a factor(s) (III) present in I and II. III is heat stable, slightly soluble in MeOH, soluble in water, dialysable, and adsorbable on Darco. III cannot be eluted from Darco with acetone or EtOH, but can be eluted with MeOH and water. The filtrate of the Darco adsorption of the dialysate and the distillate from the concentration of I under vacuum are inert. The filtrate (IV) of the Darco adsorption of II and histamine stimulate intestinal motility. The factor(s) in IV is non-protein in nature, heat stable, water soluble and non-dialysable. These data from *in vitro* studies indicate that a dialysable inhibitory and a non-dialysable stimulatory factor(s) is present in II which will produce bloat *in vivo*.

EFFECT OF EXPOSURE TO HIGH ENVIRONMENTAL TEMPERATURE AND SHEARING ON SEMEN PRODUCTION OF RAMS IN WINTER. R. H. Dutt and Paul T. Hamm, *Kentucky Agricultural Experiment Station.*

Four Southdown rams were kept in a heated room at 90° F. for one week during January. Two of the rams were sheared before they were placed in the room and two remained unsheared. Two rams kept in the unheated barn served as controls. During the last three days of the test period the average rectal temperatures for the control, the hot-room sheared and the hot-room unsheared rams were 102.2 ± .13° F., 102.4 ± .11° F., and 105.0 ± .38° F., respectively. Average pulse rates were 73 ± 1.2, 76 ± 0.9, and 68 ± 1.3, and the average respiration rates were 34 ± 1.2, 134 ± 4.9, and 178 ± 5.6, respectively, for the three groups. Rectal temperatures of the hot-room unsheared rams and the respiration rates of the hot-room sheared and the unsheared rams were highly significantly greater than those of the control rams. Semen samples were taken twice a week. Semen from the three groups of rams did not differ significantly during pre-test collections, nor at the end of the one-week test period. However, five weeks after the test period, averages of sperm cell motility for the three groups were 85, 80 and less than 10 percent, respectively. Percentages of morphologically abnormal cells were 10.0, 8.1 and 71.0, respectively. Sperm cell concentration was also lower for the hot-room unsheared rams. Semen from the hot-room sheared rams did not differ significantly from the control rams. Eight weeks after the test period there was no difference among the groups in any of the semen characteristics studied. Spermatogenic activity of the hot-room unsheared rams apparently was impaired by the treatment, whereas very little effect was found in the sheared rams.

PIG NUTRITION AND SOW REPRODUCTIVE PHENOMENA ASSOCIATED WITH EARLY WEANING. R. H. Grummer and H. L. Self, *University of Wisconsin.*

The growth and feed efficiency of pigs weaned at 21 and 56 days of age and the post-weaning reproductive phenomena in 21 Poland China and in 14 Chester White sows when their litters were weaned at 10, 21 or 56 days of age were studied. Both aged sows and 1st litter sows were included. The litters were farrowed between April 29 and May 20, 1955. Two Chester White and 8 Poland China sows were selected for reproductive observations on 10-day weaning. Of the 25 sows remaining the first 13 to farrow were assigned to suckle their litters 56 days, with the other 12 to suckle their litters 21 days. Beginning at weaning, the 21-day weaned litters received a pig starter for two weeks before being shifted to a creep ration. The 56-day weaned litters were provided with a creep ration from the 21st to the 56th day. The average pig weights for the 21-day and 56-day groups respectively were 11.7 and 11.6 at 3 weeks of age and 29.2 and 37.5 at 8 weeks of age. From the 21st to the 56th day approximately 0.85 lb. of starter and 1.2 lb. of creep feed was required to produce 1 lb. of gain in the 21-day weaned litters, while about 0.45 lb. of creep feed and 3.5 lb. of sow feed produced 1 lb. of gain in the 56-day group. Sows in the 56-day group lost an average of 14 lb. during the 3rd to 8th week suckling period. The interval to the first post-lactation estrus was over 9.4 days in the 10-day weaned sows and was 6.2 and 4.0 days in the 21 and 56-day groups, respectively. In the 10-day group two of the 10 sows (20 percent) were cystic when slaughtered. One of these had not shown heat when slaughtered at the 30th day. The 8 non-cystic sows remaining in the 10-day group averaged 12.8 ova at the first estrus, while 4 sows slaughtered in each of the 21-day and 56-day groups averaged 15.2 and 16.6 ova, respectively. Fertilization rates for the non-cystic sows in the 10-day group was 93 percent; the 21-day and 56-day groups had 91 and 98 percent, respectively.

THE EFFECT OF TWO LEVELS OF ENERGY INTAKE IN GILTS ON PUBERTY, OVULATION, FERTILIZATION, EMBRYONIC SURVIVAL AND PIGS BORN. C. E. Haines, A. C. Warnick and H. D. Wallace, *Florida Agricultural Experiment Station.*

Forty-six gilts were divided into full fed and limited fed (50 percent energy of full fed) groups to determine the effect of level of energy intake on reproduction. Each group was fed an equal quantity of protein, vitamins and minerals, and was given free access to legume-grass pastures. Gilts were checked daily for estrus before puberty and were bred at the second estrus. The average age and weight at puberty was 196.0 days and 194.2 lb. in full fed gilts and 215.5 days and 157.8 lb. in limited fed gilts. One-third of the gilts in each group were slaughtered 3 days after breeding, another one-third sacrificed 25 days after breeding and the rest allowed to farrow. The average number of ova shed by the full fed gilts killed 3 days postbreeding was 13.7 and 14.3 at the first and second estrus, respectively. The corresponding number of ova for the limited fed gilts was 10.2 and 10.4. The difference in ovulation rate between rations was statistically significant. The average number of embryos present 25 days following breeding was 11.6 in full fed gilts and 9.2 in limited fed gilts; this difference was not statistically significant. The full fed gilts farrowed an average of 10.0 pigs compared to 8.9 pigs by the limited fed females. The analysis of variance indicated no significant difference. A high energy intake was desirable for early puberty and high ovulation rate but increased the amount of prenatal death.

THE EFFECT OF STRESS ON LACTATION IN THE RAT. A. R. Hickman, R. L. Hays and N. L. VanDemark, *University of Illinois.*

Previous investigations have shown that injection of epinephrine into female rats caused a decrease in the amount of milk as tested by the weights of the litters. An experiment was made to produce a similar effect by causing the release of endogenous epinephrine due to fright. Fright was induced by directing an air blast on the female for four minutes, twice daily. Treatment started on the day after parturition and continued until the young were 28 days old. The litters were standardized to 6 and weighed daily. On the 21st day after parturition, the right anterior mammary glands from 11 females were removed for histological study. On the 28th day, the adrenal glands from 11 females were removed and weighed. Feed and water were given ad libitum. There appeared to be no correlation between adrenal weights and treatment or litter size. The litters of the twelve treated females were lighter than those of the thirteen control females by 10 percent on the 4th day, and remained 10–12 percent lighter up to the 27th day of age. On the 28th day, the litters of the control females averaged 463.3 gm. as compared to 426.3 gm. for the litters of the treated females.

A MOUSE UTERINE RESPONSE TO INJECTED RAW BLOOD SERUM. G. A. Hindery, D. L. Hill and N. S. Lundquist, *Purdue University.*

Preliminary studies to assay bovine sera for estrogenic activity have revealed a mouse uterine weight increase to injected raw blood serum. Six virgin Jersey heifers were bled at five day intervals for two consecutive estrus cycles. The bioassay was made using ovariectomized albino female mice of the Rockland-Swiss strain when 8–10 weeks of age. Each mouse was injected with a total of 0.6 ml. of serum over a 48 hr. period, sacrificed, and body and uterine weights recorded. The average uterine weight for the control groups was 20.84 mg. compared to an average of 25.10 mg. when blood serum gave the least response and 29.01 mg., the greatest response.

Wide variations occurred between animals and also between bleedings. This method shows promise as a bioassay for measuring the estrogenic activity of raw blood serum.

GROWTH PATTERNS OF LINE I HEREFORD STEERS IN RECORD OF PERFORMANCE TESTS, MILES CITY, MONTANA, 1941–54. Paul E. Howe, *Animal and Poultry Husbandry Research Branch, U.S.D.A.*

Data on Line 1 Hereford steers in ROP tests were available for 1941–1954. Three phases of feeding existed: (a) 1941–46, (b) 1946–50, (c) 1950–54; average values; TDN consumption (lb.) (a) 10.2, (b) 12.1, (c) 13.5; growth (final weight); (a) 890, (b) 970, (c) 1053 and depth of fat over rib; (m.m.) (a) 11.4, (b) 16.8, (c) 19.5. The average area of rib eye (cm.^{2}) varied from 12.2, 1942 to 9.8 '52. Growth curves on arithlog. paper showed adjustment from weaning in the first two 28-day periods and a straight line in periods 2 or 3 to 6 and 8 and 9. The test periods and average daily gain cover three phases of development, adjustment to feeding, end of rapid muscle development, and beginning of rapid fattening. Correlation of data on log. protein in whole animal (Y) with log. age-days (X_1) and log. TDN consumed (X_2) (log $Y = .4290 - .3439\ X_1 + .7391\ X_2$ ($4 = .99$)) from Missouri and Minnesota data did not seem to hold. Environmental effects, especially birth to weaning, influence subsequent development. Growth curves from data grouped by 50-lb. intervals for years and by 10-day intervals for year-groups, showed similarities in weight-groups, but not year-groups. Slopes of growth curves Periods 4–6 decreased with initial weights; 300 lb.; (a) .0043, (b) .0050, (c) .0050 to 450+ lbs.; (a) .0035, (b) .0036, (c) .0041 and less for the slower rates of Periods 8 and 9, 300 lb.; (a) .0031, (b) .0025, (c) .0028 to 450+ lb.; (a) .0023, (b) .0024, (c) .0023. Average area of rib eye tended to increase with feeder weight; but not when data were grouped in 10 day-age periods. Plots of individual growth curves and use of slopes in ROP feeding experiments is practicable and useful.

RABBITS AS SUBSTITUTES FOR CATTLE IN THE STUDY OF CLIMATIC PHYSIOLOGY. H. D. Johnson and S. Brody, *University of Missouri.*

With the conspicuous exception of absence of rumen with associated compensatory adjustments, rabbits are similar in most respects to British breeds of cattle in their nutritional and climatic physiology. Like British cattle, they react to temperature like arctic species, very intolerant to high temperatures and tolerant to low temperatures. As in cattle, there is an explosive rise in respiration rate at about 70° F.; a rapid rise in rectal temperature 80°–85° F. with corresponding declines in feed consumption, heat production, and thyroid activity. The surface (skin and hair) temperature meet with air temperature at about 105° F. environment. The rectal temperature increases from 103° F. at 60° F. environment, to 106° F. at 97° F. environment. The feed consumption declines from 110 gm. per day at 60° F. to 3 gm. per day at 97° F. environment. The respiration rate increases from 80 per minute at 60° F. environment, to 400 at 100° F. environment. Thyroid activity as measured by release of I^{131} from the thyroid declined from 13 empirical units at 50° to 1.2 at 95° F. Comparisons were also made on 24 growing rabbits kept at 83° and 48° F. chambers. By comparison with the 48° F. environment group, 7-month old rabbits in an 83° F. environment had 1° F. higher rectal temperature, 41 percent lower thyroid activity, 19 percent lower heat production, 33 percent lower feed consumption, 12.5 percent lower body weight. Slides will illustrate the results.

EFFECT OF CHLORTETRACYCLINE (AUREOMYCIN), STILBESTROL AND CHLORTETRACYCLINE-STILBESTROL SUPPLEMENTS ON FATTENING LAMBS. P. S. Jordan, R. M. Jordan and H. G. Croom, *University of Minnesota.*

To determine the value of chlortetracycline (Aureomycin), stilbestrol, and a combination of chlortetracycline and stilbestrol, 8 lots of 10 lambs each were full-fed corn and alfalfa hay at two concentrate-roughage ratios—45–55 and 35–65. A tenth of a lb. of soybean oil meal was fed per lamb daily and was used as the carrier for the antibiotic and/or the stilbestrol. The following treatments were super-imposed on each of the concentrate-roughage rations: 21.6 mg. of chlortetracycline per lamb daily; 2 mg. of stilbestrol administered orally per lamb daily, and 21.6 mg. of antibiotic and 2 mg. of stilbestrol per lamb daily. At neither concentrate-roughage ratio did the addition of antibiotic, stilbestrol or a combination of the two significantly affect the rate of gain, feed consumption or feed efficiency. When chlortetracycline or chlortetracycline-stilbestrol was included in the ration greater gains were made at the higher concentrate-roughage ratio than at the lower ratio. Slightly higher grading carcasses were obtained in the lots fed antibiotic or antibiotic-stilbestrol.

RELATIVE HEAT TOLERANCE OF SANTA GERTRUDIS, BRAHMAN, AND SHORTHORN HEIFERS. H. H. Kibler and Samuel Brody, *University of Missouri.*

Heat tolerance comparisons were made on 18 animals. Three of each breed were kept at a temperature of 80° F. Similar groups were kept at 50° F. Relative humidities averaged 55 percent for both groups (vapor pressures, mm Hg.: 12 at 80° F., 4.5 at 50° F.). Averages of daily measurements for 8 months show higher rectal temperatures at 80° F. than at 50° F. by 0.4° F. in the Brahmans, 0.3° F. in the Santa Gertrudis, and 2.1° F. in the Shorthorns. Mean rectal temperatures at 80° F. in corresponding order were 102.2, 102.5, and 104.3. Respirations per minute were higher at 80° F. than at 50° F. by 9.8 in the Brahmans, 19.1 in the Santa Gertrudis, and 43.7 in the Shorthorns. Mean respiration rates at 80° F. in corresponding order were 31.9, 47.6, and 91.8. The above differences were all significant at the 1 percent level of probability. Pulmonary ventilation rates were complicated by body weight. Per animal mean rates at 80° F. were higher than at 50° F. by 24 percent in the Brahmans, 22 percent in the Santa Gertrudis, and 20 percent in the Shorthorns. In liters per minute the corresponding rates at 80° F. were 34.0, 48.6, and 62.9. Per unit weight the corresponding rates were higher at 80° F. than at 50° F. by 16 percent, 28 percent, and 71 percent. The Shorthorns grew slowly at 80° F. At 10 months their mean weights were 557 lb. at 50° F. and 387 lb. at 80° F. These comparisons show that the 80° F. environment produced considerable stress in the Shorthorns but not in the Brahman and Santa Gertrudis.

THE PRODUCTION OF CARBAMATE *IN VIVO* AND *IN VITRO* BY RUMEN MICROORGANISMS. R. P. King and W. H. Hale, *Iowa State College.*

The administration of the calcium salts of carbamino acids and ammonium carbamate by intravenous injection, injection into the abomasum, and oral drench to ruminating lambs produces a syndrome similar to an acute urea toxicity. The formation of carbamate, $^{RNHCOO-}$, exist within the rumen under certain conditions. It has been demonstrated that carbamate is readily absorbed from the rumen into the blood with subsequent toxic effects to the animal. High blood ammonia values are found in ruminants on certain types of fresh legume forages.

This suggests a high ammonia concentration within the rumen and the possibility of forming carbamate resulting in death during acute bloat. Acutely bloated animals, however, have not been available for carbamate toxicity studies. The formation of carbamate by rumen microorganisms *in vitro* under varied pressures of carbon dioxide and ammonia and from various nitrogen sources will be discussed. Also the presence of carbamate *in vivo* of a ruminant when fed various levels of nitrogen sources is discussed. The methods of preparation of carbamino acid calcium salts and ammonium carbamate with the method of estimating carbamate as carbonate are given.

THE EFFECT OF PROTEIN LEVEL ON RESPONSE FROM STILBESTROL WHEN FED AND WHEN IMPLANTED IN FATTENING STEERS. Earle W. Klosterman, V. R. Cahill, Orville G. Bentley and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Nine lots of seven steers each, weighing approximately 725 lb. initially, were fed ground ear corn, hay and minerals for a 126-day period. Three lots served as controls, three lots were implanted subcutaneously in the ear with 60 mg. of stilbestrol per head at the start of the experiment, and three lots were fed 10 mg. of stilbestrol per head daily. Three levels of protein were fed with each treatment. There were highly significant differences in average daily gains between steers fed the various levels of protein and also between the controls and those which received stilbestrol. There were no significant differences in gains between the steers which were implanted and those which were fed the stilbestrol. There was a significant interaction between level of protein and stilbestrol treatment. The response in daily rate of gain from stilbestrol, average of both methods of administration, was 0.51, 0.36 and 0.03 lb. when 1.5, 0.75 and no soybean oil meal, respectively, was fed per head daily. In addition to gains and feed consumption, marketing, slaughter and carcass data were obtained.

SOME FACTORS AFFECTING THE DETERMINATION OF PLASMA PROTEIN-BOUND IODINE USING THE ALKALINE FUSION-CERIC SULFATE METHOD. Harry D. Lennon, Jr. and John P. Mixner, *New Jersey Agricultural Experiment Station.*

In a factorial experiment to study the effect of certain variables on the determination of plasma protein-bound iodine by the Brown method (Jour. Clin. Endocr. Metab. 13:440, 1953) with slight modification, four samples of dairy cattle whole blood and plasma were stored for intervals of 0, 1, 3 and 6 days at temperatures of −20° C., +2° C. and +25° C. prior to assay. Plasma was recovered from whole blood for assay. Duplicate fusions (which involved manipulations of precipitation, washing, drying and ashing of plasma proteins) on each sub-sample and duplicate colorimetry on each fusion were performed. It was found that whole blood stored at −20° C. was not appropriate for assay, due to a progressive decrease in plasma PBI values with storage. The effects due to temperature and time of storage of plasma were not statistically significant. The standard error of a single PBI determination was 0.43 mcg. percent and a coefficient of variation of 8.31 percent. Of the variance attributable to fusion and colorimetry effects, 85.9 percent was contributed by fusion and 14.1 percent by colorimetry. Based on this analysis, our standard method of assay involves a single colorimetric determination on each of three separate fusion tubes, whereby the standard error of a mean determination is reduced to 0.25 mcg. percent with a corresponding decrease in the coefficient of variation to 4.80 percent.

A TECHNIQUE FOR ESTIMATING THE THYROXINE SECRETION RATE OF DAIRY CATTLE. R. C. Lewis, E. P. Reineke and J. R. Lodge, *Michigan State University.*

The daily thyroxine secretion rate of dairy calves has been estimated by a substitution technique in which the thyroid gland was progressively inhibited by administered l-thyroxine. Subcutaneous or intravenous injections of 150 uc. of I^{131} were made and 48 hr. later the gamma radiation from the thyroid region of the neck determined. Four to 10 days later a second external thyroid count was made. Oral administration of .2 gm. of thiouracil per kg. of body weight daily was begun at this time and continued for the duration of the trial. The thiouracil, administered by capsule, was divided into two daily doses given at about 12 hr. intervals to prevent recycling of iodine through the thyroid. Three further thyroid counts were made on alternate days to establish the I^{131} output rate. Daily subcutaneous administration of purified l-thyroxine was then begun with increments added every second day. External thyroid counts were taken at the end of the two day period on each level of thyroxine. These values were calculated as the percent of the previous count and the thyroxine secretion rate assumed to be between the amount required to raise the percentage above 100 and the last previous dosage. With this technique, the daily thyroxine secretion rate of a series of calves was found to range from .55 to .85 mg. per 100 lb. or 1.88 to 3.36 mg. per calf.

RATE OF WATER EVAPORATION FROM VARIOUS AREAS OF A NORMAL BODY SURFACE AND WITH SWEAT GLANDS INACTIVATED UNDER HOT CONDITIONS. R. E. McDowell, H. F. McMullan, M. Wodzika, D. H. K. Lee and M. H. Fohrman, *Dairy Husbandry Research Branch, ARS., U.S.D.A.*

Using a capsule technique, a systematic study was made of the rate of evaporation at 16 different points on one animal exposed to standard hot conditions of 105° F. and 34 mm. Hg vapor pressure. The results show highly significant differences between rates of evaporation at different points. The rate was lowest on the legs and mid-belly line, highest on the mid-neck, and intermediate over the remainder of the trunk. Data collected on 25 dry Jersey cows and 20 dry Sindhi-Jersey (F_1) crossbred cows at 105° F. from areas on the forechest, paunch and dewlap show that evaporation from the area of the dewlap is slightly lower than that from the forechest and paunch in the Jerseys, and distinctly lower in the Sindhi-Jerseys. The mean rates of evaporation from the forechest and paunch was not significantly different for the two groups. This evidence gives little support for either of the ideas; (a) that the Sindhi-Jersey crosses owe their superior heat tolerance to a greater rate of evaporation from the skin; or (b) that the dewlap is a more effective evaporating surface than the rest of the skin. Iontophoresis with formaldehyde was found to reduce the rate of evaporation observed by the capsule method. This, combined with the absence of any evaporation from rabbit skin, which is devoid of morphological glands, strengthened the hypothesis that the greater part of the moisture evaporated from the skin of the cow is provided through the agency of the glands to be found in histological sections of the skin.

THE USE OF OXYTOCIN FOR INITIATING PARTURITION AND REDUCING FARROWING TIME IN SOWS. M. E. Muhrer, O. F. Shippen and J. F. Lasley, *University of Missouri.*

The purpose of this investigation was to determine whether or not oxytocin could be used to either initiate or hasten farrowing in the sow. The study involved 79 sows and gilts of Hampshire, Berkshire, Poland China, Landrace and Poland

China × Landrace breeding. Oxytocin (Armour Lab.) injections were made and farrowing data obtained on 36 sows with similar data collected on 43 control animals. Intramuscular injections were easier to administer than intravenous injections and gave a more sustained stimulation. Oxytocin was injected to stimulate parturition when a sow was believed to be within 24 hours of farrowing as evidenced by the breeding record and by the presence of milk in her teats. In 84 percent of the cases where milk was available in the sow's teats the injection of 20 or more units of oxytocin initiated parturition. In these cases the average time between oxytocin injection and the birth of the first pig was 3.5 hours and the length of the farrowing period was an average of 2.2 hours. When oxytocin was injected after the sow had started to farrow the length of the farrowing period was an average of 2.5 hours. The control animals required on the average 3.3 hours to farrow. Oxytocin affects the initiation of parturition and reduces the farrowing time but no adverse effects were observed in any of the experimental sows or their pigs.

TOXIC FORAGES PRODUCED IN A DROUGHT AREA. M. E. Muhrer, A. A. Case, G. B. Garner and W. H. Pfander, *University of Missouri.*

Following a severe drought in central Missouri during the summer of 1954 the forages of this area were in many cases toxic to animals. Cattle were affected more than other animals and corn stalks seemed to be more toxic than other feeds. Toxicity symptoms appeared in the animals in from 5 to 7 days and death occurred 2 to 24 hours later. Symptoms are those of a rapidly progressive intoxication characterized by extremely severe anoxia. Unsteadiness, wobbly gait, and motor spasms rapidly progressed to convulsions terminating in death. Severe cyanosis marked by rapid shallow respiration and a weak, rapid pulse were usual. Some cows were blind and many developed mania. Abnormal blood bonds were present in the natural outbreaks: among those were nitrosohemoglobin and methemoglobin. The forages contained as much as 8 percent potassium nitrate equivalent and usually showed evidence of mold growth. In tests with Guinea pigs, rats, and sheep nitrite was found to be 10 times as toxic as nitrate thus making the conversion of nitrates to nitrites in the rumen of added significance. Guinea pigs fed the toxic forages showed degeneration and fatty infiltration of the liver on autopsy. These symptoms could be produced by feeding nitrate and were also observed in cattle killed by the toxic forages. However, it is believed that in addition to the nitrate other factors such as molds and smut contributed to the toxicity of forages produced in a drought area.

THE CONTROL OF ESTRUS IN THE BEEF HEIFER BY USE OF PROGESTERONE AND GONADOTROPHIN. John E. Nellor and Harold H. Cole, *University of California.*

In a series of studies extending over a three year period it has been demonstrated, with Hereford heifers weighing from 550–1200 lb., that a single injection of 540–1120 mg. of crystalline progesterone suspended in a .3 percent starch emulsion is capable of inhibiting estrus for at least 15 days, of inhibiting existing follicular growth and, if treatment is given on the same day, of synchronizing follicular development in a group of heifers with unrelated estrous cycles.

Twelve of seventeen progesterone treated heifers (540–800 lb.) came in heat within a two day range for their group. Different groups receiving the same dosage of different progesterone preparations showed a range from injection time to heat of 16–23 days, reflecting varying inhibition time dependent on the preparation. Pregnancy resulted in the two heifers inseminated at this post-injection estrus. In a group of over-finished heifers estrus and ovulation did not occur in 8 out of the 9

heifers treated, although synchronization of follicular growth was demonstrated and ripe follicles were present in the ovaries.

A singe injection of equine gonadotrophin (750–2140 I.U.) 15 days post-progesterone injection was followed by estrus 1–4 days later in 73 of 87 treated heifers. Multiple ovulations were encountered at the higher levels of gonadotrophin (2140 I.U.). Estrus occurred one day post-gonadotrophin injection in 47 of 68 heifers receiving 750 I.U. The conception rate was less than 20 percent with this combined treatment.

Although inhibiting follicular growth and estrus activity, 1120 mg. of exogenous progesterone did not influence the pituitary content of the treated heifers, as regards FSH, ICSH, TSH and GH activity.

PRELIMINARY OBSERVATIONS ON LUMINAL FLUIDS OF THE FEMALE BOVINE REPRODUCTIVE ORGANS. Durward Olds and N. L. VanDemark, *University of Illinois.*

Pooled and individual samples have been used to obtain limited data on the composition of fluids from the vaginas, uteri, oviducts and follicles of normal non-pregnant cows at slaughter. Considerable epithelial tissue was found in the material obtained from the oviducts and uterus. Uterine fluid, at about mid-cycle, contained many epithelial cell nuclei (536 million per ml.). Follicular fluid contained 7.5 percent dry matter, of which 9.3 percent was ash. On a 100 ml. basis the follicular fluid contained an average of 313 mg. Na, 36 mg. K, 12 mg. Ca, 3 mg. P, 309 mg. Cl^-, 0.96 gm. N and 37 mg. reducing substance (ca. as glucose). The pH averaged 7.1, the oxidation-reduction potential —.085 volts and the osmotic pressure 273 milliosmols. Fluids from the oviducts averaged 243 mg. Na, 223 mg. K and 11 mg. Ca per 100 gm. Uterine fluids contained 10 percent dry matter, of which 10 percent was ash and 15 percent was ether extractable. Each 100 ml. contained about 278 mg. Na, 183 mg. K, 15 mg. Ca, 65 mg. Cl^-, 1 gm. N and 50 mg. reducing substance. The average pH was 7.4, the oxidation-reduction potential —.257 volts and the osmotic pressure (one sample) 370 milliosmols. Vaginal mucus contained 2.4 percent dry matter, of which 41 percent was ash. An average of 198 mg. Na, 166 mg. K, 11 mg. Ca, 0.262 gm. N, and 5.4 mg. reducing substance per 100 ml. was found in vaginal mucus.

BREEDING EFFICIENCY IN EGYPTIAN CATTLE AND BUFFALOES. Mohamed M. Oloufa, *Cairo University, Egypt.*

Natural service was the only method of breeding used at the farm of the Animal Production Department, Cairo University at Giza. During the last 13 years, a total of 650 buffaloes and 632 cows was available. The females were not served before 60 days after parturition. Pregnancy was established by rectal palpation 60 days after service if the female did not return to heat. Conception rate was arrived at by calculating the percentage of pregnancies to the total number of first services. In cattle, conception rate was 35.1 percent, while it was 36.2 percent in buffaloes, with a difference that lacked statistical significance. In both cattle and buffaloes, conception rate was particularly low during the post-war years of 1945, 1946 and 1947. This was probably due mainly to the scarcity of feed during those years. The interval from parturition to first estrus in cattle averaged 43 days (ranging from 22 to 96 days); whereas the average in buffaloes was 67 days (ranging from 31 to 113 days). The correlation coefficients between conception rate and the interval from parturition to first estrus were 0.036 and 0.042 in cattle and buffaloes, respectively. These coefficients were not statistically significant. In both cattle and buffaloes, heifers required more services per conception than older animals.

THE EFFECT OF ESTROGENIC AND ANDROGENIC SUBSTANCES ON GROWTH AND CARCASS COMPOSITION OF CATTLE. T. W. Perry, F. N. Andrews, Martin Stob and W. M. Beeson, *Purdue University.*

Two trials were conducted—one with 450-lb. calves and the other with 750-lb. yearling cattle—to study the effect of oral hormone-like substances on growth and upon such characteristics as carcass grade, dressing percentage and carcass composition. Four lots of calves were fed a fattening ration of corn, Supplement A, corn silage, hay and minerals. Growth rates for the 179-day trial were: no hormone, 2.10 lb. per day; 10 mg. stilbestrol, 2.50 lb.; 10 mg. dienestrol, 2.32 lb.; 10 mg. hexestrol, 2.27 lb. Four lots of yearlings were fed a similar fattening ration and their daily growth rates for the 179-day trial were: no hormone, 2.35 lb.; 10 mg. stilbestrol, 2.63 lb.; 5 mg. stilbestrol and 50 mg. testosterone, 2.62 lb.; 175 mg. testosterone, 2.44 lb. Marketing shrink, dressing percentage, and U .S. Government Grades, respectively, for the two trials were: Calves, no hormone, 2.3 percent, 62.1 percent, 9 Choice; 10 mg. stilbestrol, 4.4 percent, 62.7 percent, 7 Choice—1 Good; 10 mg. dienestrol, 4.6 percent, 62.5 percent, 5 Choice—3 Good—1 Commercial; 10 mg. hexestrol, 2.7 percent, 61.9 percent, 5 Choice—4 Good; Yearlings, no hormone, 2.3 percent, 60 percent, 7 Choice—2 Good; 10 mg. stilbestrol, 2.0 percent, 58.7 percent, 4 Choice—4 Good—1 Commercial; 5 mg. stilbestrol and 50 mg. testosterone, 3.2 percent, 62.1 percent, 2 Choice—6 Good—1 Commercial; 175 mg. testosterone, 3.3 percent, 59.2 percent, 4 Choice—5 Good. The effect of these treatments on the chemical composition (moisture, protein and fat) will be reported.

THE INFLUENCE OF ORAL ADMINISTRATION OF DIETHYLSTILBESTROL UPON ESTROGENIC RESIDUES IN THE TISSUES OF BEEF CATTLE. R. L. Preston, E. Cheng, C. D. Story, P. Homeyer, J. Pauls and W. Burroughs, *Iowa Agricultural Experiment Station.*

Estrogenic activity of tissues from beef cattle fed various levels of stilbestrol was determined by two methods of assay, using the increase in uterine-weight of intact, immature female mice as the criteria of response. Dried lean, fat, liver, offal, heart and kidney samples were assayed by incorporating them into a mouse diet and fed to respective groups of eight to ten mice for ten days. in no case were the average uterine weights obtained from mice fed the tissues of cattle receiving stilbestrol significantly heavier (P .05) than those from control cattle. Statistical analysis of the standard curves indicated that the assay procedure was sufficiently sensitive to detect as little as 1.4 parts of stilbestrol per billion parts of fresh tissue. The tissues were assayed by a second method in which various levels of stilbestrol were added to the diets containing the respective tissues from control and stilbestrol-fed cattle. Each added level of stilbestrol for each tissue was fed for four or five days to four replicates of five mice each. Using this method, two assays were made on the lean, fat and liver tissues. No statistical significance (P .05) was obtained between the tissues from control and stilbestrol-fed cattle indicating there was no accumulation of estrogenic residues.

THE EFFECT OF CERTAIN ACUTE "STRESS" CONDITIONS ON THE PLASMA LEVELS OF 17-HYDROXYCORTICOSTEROIDS AND PROTEIN-BOUND IODINE IN DAIRY CATTLE. W. G. Robertson, H. D. Lennon, Jr., W. W. Bailey and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

Sixteen cows suffering from various acute stress conditions including surgery, acute mastitis, milk fever, complete uterine prolapsis, general systemic infections, retained placenta, metritis and nephritis were used in this study. Plasma

17-hydroxycorticosteroid levels were determined by the method of Robertson and Mixner (JOUR. ANIMAL SCI. 13:1030, 1954) while plasma protein-bound iodine levels were determined by the method of Brown *et al.* (Jour. Clin. Endoc. Metab. 13:440, 1953). Plasma 17-hydroxycorticosteroid levels showed a mean of 157 percent increase over normal controls (4.58 mcg. percent) while plasma protein-bound iodine levels remained within normal limits. Blood sugar values for the stressed animals were slightly higher than normal and blood ketone values fell within the normal range. The results of this investigation support the hypothesis that a major defense mechanism of the body is increased adrenal cortical function with resultant increases in the circulating 17-hydroxycorticosteroid levels. The clinical effectiveness of supportive steroid therapy in stressed animals was evidenced through improved appearance and a more rapid recovery rate. It is postulated that exogenous steroid exerts a sparing action on the adrenal cortical reserves of the stressed animal. The results of this study would tend to indicate that the thyroid gland plays a more passive role in stress conditions of this nature.

PITUITARY GONADOTROPINS IN THE EWE AT DIFFERENT STAGES OF THE ESTROUS CYCLE. John A. Santolucito and H. H. Cole, *University of California.*

Twenty-nine Corriedale ewes were checked for normal estrous cycles. After exhibiting one or more cycles they were slaughtered at intervals so that at least five ewes were represented at each of the following stages: 4 hr., 35 hr., 5 days, 10 days and 15 days post-estrus. At the time of sacrifice, the pituitaries and blood were taken for assay of FSH, ICSH, and Prolactin. Also at this time, fresh ovulations were confirmed in all of the ewes in the 35-hour post-estrus group. Each ewe pituitary was assayed individually. The ovarian weight response of immature female rats given a standard augmenting dose of HCG, was used as an index of FSH activity. For ICSH, the ventral prostate weight response of immature hypophysectomized male rats was used. For prolactin, the pigeon crop gland response was used. The results suggest that pituitary FSH falls from a maximum at 4 hours post-estrus to a minimum at 35 hours post-estrus. Pituitary ICSH, on the other hand, shows an initial rise from 4 hours post-estrus which continues to a maximum at 10 days post-estrus. It was of interest to find that the pituitary Prolactin also showed an initial rise from 4 hours post-estrus and closely paralleled the ICSH curve throughout the cycle.

A COMPARISON OF REPRODUCTIVE EFFICIENCY OF SOWS AT THE FIRST AND SECOND POST-LACTATION HEATS. H. L. Self, *University of Wisconsin.*

Observations were made on the reproductive phenomena at the first or second post-lactation heats of 95 sows. There were 8 genetic groups made up of outbreds of the Duroc (D) Poland (P), and Yorkshire (Y) breeds and crosses of the Duroc-Yorkshire (DY), Poland-Duroc (PD) and Poland-Yorkshire (PY), an inbred Chester White (CW), and an inbred-Landrace-Inbred Chester White (LAK) cross. All were first litter sows except in the Duroc (D) and Yorkshire (Y) where both first litter and aged sows were observed. For analysis the records of the aged sows were treated separately. The interval from weaning to first estrus ranged from 2 to 80 days (mean of 8.8; mode of 4). Seventy-seven (81 percent) of the females showed estrus during the first week. No sows were observed in heat during lactation. Means for the groups were: P—4.0; D—9.5; Y—8.7; PD—6.6; PY—5.5; DY—9.4; CW—16.6; LAK—13.1; D (aged sows)—4.9; and Y (aged

sows)—7.8. There was no significant difference between groups. Within each genetic group (except the LAK) females were allotted alternately as they showed the first post-lactation heat to either a first heat or a second heat group for slaughter and ovulation data. The 15.3 ova average at first heat did not differ significantly from the 16.2 ova second heat mean (P 0.05). The breed means were P—10.7; D—15.7; Y—13.8; PD—13.3; PY—14.0; DY—14.4; CW—16.5; D (aged)—17.9; and Y (aged)—18.6. These differed significantly (P less than 0.01). Observations on back fat thickness and carcass weight indicate a highly significant relationship between body weight and ovulation rate when back fat is held constant.

TOXIC CONCENTRATES FROM LADINO CLOVER. R. A. Shaw and H. D. Jackson, *Purdue University*.

Concentrates from various extracts of ladino clover, a bloat-producing forage, were tested for their physiological effects. Dried ladino clover was extracted with benzene and the extract filtered. The benzene residue was re-extracted with 50 percent ethanol and the extract concentrated and fractionated with butanol to remove saponins. The low-saponin aqueous concentrate from this fractionation was assayed. The saponin-rich butanol phase and the benzene extract were each converted into an aqueous solution before assay. The ladino clover concentrates were assayed for their effect on oxygen consumption and on contraction of smooth muscle from the rat. The low-saponin aqueous concentrate gave the greatest inhibition of oxygen consumption and caused paralysis of the muscle. Sheep red cells were also treated with the concentrates; red cell cholinesterase activity, which reflects the animal's capacity for nerve transmission, was reduced to some degree by all concentrates. When sheep were injected I.V. with the ladino clover concentrates the low-saponin aqueous fraction caused the animals to fall and produced miosis and severe tetany. The benzene concentrate and the saponin-rich butanol concentrate caused milder symptoms. Data suggest that ladino clover contains substances, other than saponin, which are toxic to sheep if injected intravenously. At least part of this inhibition appears due to anticholinesterase activity. Constituents from the active concentrates are possibly associated with bloat on ladino clover pasture.

SAFETY CONSIDERATIONS IN USING DIETHYLSTILBESTROL AS A GROWTH PROMOTANT IN FEEDER CATTLE. W. C. Sherman, C. R. Adams, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Inc.*

Use of diethylstilbestrol in cattle fattening rations has necessitated research on possible effects upon other animals, especially breeding animals, which may accidentally receive feeds containing stilbestrol. Bred gilts following steers receiving 10 mg. stilbestrol per day showed no abnormality in farrowing. Open gilts following such steers later showed normal breeding performance. Bred gilts fed 10 mg. stilbestrol per day for thirty days before farrowing had normal litters. Open gilts fed 10 mg. of stilbestrol per day for 36 days prior to breeding showed breeding abnormalities with delays in coming into heat, and required repeated services before settling. Feeding lactating dairy cows 10 mg. diethylstilbestrol per day had no effect upon milk production nor was there a carry-over of estrogen into the milk. Experiments with pregnant Holstein heifers, yearling heifers and 6.5 month old heifers are in progress with stilbestrol fed at the rate of 1.5 mg. per 100 lb. body weight per day up to a maximum of 10 mg. daily intake. No abnormalities in calving or breeding have appeared to date. Feeder lambs which were fed stilbestrol at levels of 6, 12 and 24 mg. per day for 35 days, and double those levels thereafter, have shown no side effects. Broiler chicks have received stilbestrol in the feed at levels of 0.5, 2 and 10 gm. per ton. Growth

responses have been observed in the males but none in the females. Atrophy of the tests and underdevelopment of the combs of the males, and hypertrophy of the ovaries of the females were observed.

EFFECT OF DIETARY MOLYBDENUM ON HEMOGLOBIN, RED AND WHITE CELLS AND DIFFERENTIAL WHITE BLOOD CELLS IN RATS. R. L. Shirley, Winnie R. Teeters, J. L. Herring and G. K. Davis, *University of Florida.*

Forty weanling rats were divided into two dietary groups containing equal numbers of each sex. They were fed a synthetic ration containing 25 percent protein with one group receiving less than 1 p.p.m. and the other 100 p.p.m. of Mo. Values for the various blood components were determined after 90 and 120 days on the diets. Statistical analysis showed that the high Mo dietary group had higher concentrations of total white cells and lymphocytes, at the 0.01 level of significance; the neutriphiles and eosinophiles were markedly higher and the basophiles much lower in the high Mo group. The dietary Mo had no effect on hemoglobin, red blood cells and monocytes. The males had values that were significantly greater than the females for hemoglobin, red cells, total white cells and lymphocytes.

STRATIFICATIONS AND KINETIC CHANGES IN THE INGESTA OF THE BOVINE RUMEN. P. H. Smith, H. C. Sweeney, J. R. Rooney, K. W. King, and W. E. C. Moore, *Virginia Agricultural Experiment Station.*

Samples of ingesta from the top and bottom of the rumen of two 2-year old fistulated steers were taken at hourly intervals over a twelve-hour period including two feedings. These were analyzed for crude fiber, ash, E.E., total nitrogen, ammonia, non-protein nitrogen, water-soluble sugars, alcohol-soluble sugars, volatile fatty acids, and the digestion of cellulose *in vitro*. In all instances except alcohol-soluble sugars significant or highly significant differences were observed between the top and bottom samples. Concentrations of all factors measured except E.E. and the amount of cellulose digestion were significantly higher in top samples. These data together with the significant time fluctuations indicate that hay and grain particles follow distinctly different physical pathways in traversing the rumen. The data also indicate that stomach tube samples of rumen ingesta cannot be interpreted as being representative of the ingesta as a whole. In a control experiment, duplicate samples were taken from both the top and the bottom of the rumen of a normal (unfistulated) mature Holstein cow by rumenotomy three hours after the morning feeding. These data show the same stratification seen in the samples from the steers. In additional analyses, pH and titratable alkalinity to pH 5.0 were significantly higher in bottom than in top samples. Observation of stratification in the rumen of the normal cow establishes that the phenomenon is typical of a variety of types of animals and that it is not an artifact resulting from fistulation.

THE EFFECT OF HORMONE ADMINISTRATION ON THE FEED LOT PERFORMANCE, CARCASS QUALITIES, AND REPRODUCTIVE ORGANS OF FEEDER LAMBS. Walter H. Smith, T. Donald Bell, A. B. Erhart and D. L. Mackintosh, *Kansas State College.*

An experiment was conducted at the Garden City Branch Kansas Experiment Station to study the effects of hormone administration upon several characteristics of feeder lambs. Four lots of 48 Wyoming whiteface lambs were used. All received a basal fattening ration for 105 days. The treatments were as follows:

Lot I, control; Lot II, individual initial implantation of 6 mg. of diethylstilbestrol; Lot III, individual initial implantation of 10 mg. of estradiol and 250 mg. of progesterone; Lot IV, daily oral administration of 2 mg. of diethylstilbestrol per head. The average daily gains were .26, .32, .33, and .32 lb., respectively. Ten lambs from each lot were taken to Manhattan for slaughter. The average live shipping shrinkages were 4.6 percent for lots I and II; 5.7 percent, lot III; and 5.1 percent, lot IV. The average carcass grade for lots I and II was choice; lots III and IV were one-half grade lower. Measurement showed that all hormone treatments increased the size of the accessory reproductive glands and bladders. The remainder of the lambs were slaughtered at Kansas City. The average live shipping shrinkage for lot I was 11.97 percent; lot II, 12.34 percent; lot III, 11.29 percent; and lot IV, 13.55 percent. The respective average lot yields were 52 percent, 51 percent, 50 percent, and 51.5 percent. The average carcass grade of lot I was choice. Comparatively, lot II was one-half grade lower; lot III, two-thirds grade lower; and lot IV, one-third grade lower. Lot II had the highest percentage of yearling carcasses.

METABOLISM OF STILBESTROL WITH LAMBS. C. D. Story, E. W. Cheng and W. H. Hale, *Iowa Agricultural Experiment Station.*

Metabolism studies with lambs fed rations containing different levels of stilbestrol were conducted to determine the daily excretion of stilbestrol in feces and urine. The estrogenic activity of the ration, feces and urine was measured by the mouse-uterine-weight response technique. With lambs receiving 2 mg. of stilbestrol in the daily ration, approximately 50 percent of the daily intake of stilbestrol was excreted in feces and 10 percent in the urine. A further purpose of these studies was to determine the influence of orally administered stilbestrol upon digestibility of protein and total dry matter in the ration of lambs. In one trial nitrogen retention was also measured. With additions of 0, 2 and 4 mg. of stilbestrol to the daily ration in successive metabolism trials, digestibility of the dry matter of the ration was 69.8, 73.5 and 77.7 percent, respectively. A part of the increase in digestibility of the dry matter was accounted for by increased digestibility of the nitrogen fraction. Also, nitrogen retention in these lambs increased with increasing levels of stilbestrol intake.

GROWTH AND HEMATOLOGY OF HEREFORD HEIFERS FED TRACE MINERALS, EXCESS CALCIUM, AND VARIOUS ROUGHAGES. Melvin J. Swenson, G. K. L. Underbjerg and Dennis D. Goetsch, *Kansas State College.*

Effects of dietary trace minerals, excess calcium, and various roughages on growth and hematology of 36 Hereford heifers were investigated. The hematology included erythrocyte counts, hemoglobin, hematocrit, leucocyte counts, calcium, phosphorus, mean corpuscular volume of erythrocytes, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration. Trace minerals had little effect on growth but increased the size of the erythrocytes and the mean corpuscular hemoglobin at the 5 percent level of significance. In one experiment the trace minerals improved the haircoats and general appearances of the calves when a low quality prairie hay was fed. The prairie hay had been exposed to abundant rain after cutting. Excess calcium with a Ca:P ratio of 10:1 with the phosphorus requirement being met impaired the growth rate of the calves significantly. Excess dietary calcium produced no significant change in the blood constituents. Alfalfa hay fed at the rate of 1.5 to 2.0 lb. per head daily did not stimulate the growth rate of the calves when rations containing adequate protein, energy, calcium, phosphorus, and carotene were fed. Alfalfa hay improved the

general appearance of the calves as the trace minerals did when the low quality prairie hay was fed. Trace minerals were of little additional value when alfalfa hay was included in the ration. Alfalfa hay increased the size of the erythrocytes in the circulating blood. These changes were significant at the 5 percent level. Wheat straw proved to be a valuable roughage when properly supplemented with protein, vitamin A, energy, and minerals.

STIMULATION IN GROWING-FINISHING PIGS BY ORALLY ADMINISTERED STILBESTROL WITH OBSERVATIONS ON THE DEVELOPMENT OF CERTAIN ORGANS. Bruce Taylor, Damon V. Catron, Gordon C. Ashton and Wise Burroughs, *Iowa Agricultural Experiment Station.*

Levels of stilbestrol of 0, 5, 10, 20, 40, 80, 160, 320, 640 and 1280 mcg. per lb. of ration were fed in two experiments to a total of 120 growing-finishing pigs from 33 to 200 lb. in weight. The feeding of stilbestrol had no significant affect on rate of gain or feed efficiency. Differences in live probe measurements, dressing percentages, and in carcass shrink were small and not statistically significant. The gilts fed 320 mcg. or more of stilbestrol per lb. of ration developed gross enlargement of the vulva by the third day of the trial, with the degree of enlargement varying with the level of stilbestrol fed. The gilts fed 160 mcg. of stilbestrol per lb. of ration developed slight enlargement of the vulva by the eighth day of the experiment, but this condition was not observed in the gilts on any lower level. Enlargement of the teats, in gilts, and of the rudimentary teats in barrows was evident by the 30th day of each experiment at those levels that stimulated the size of the vulva. The feeding of stilbestrol at levels of from 5 to 1280 mcg. per lb. of ration produced a significant increase in the diameter of the cervix and a significant increase in the weight of the reproductive tract. The 10 mcg. of stilbestrol per lb. of feed level increased the size of the ovary in both experiments, whereas all other levels of stilbestrol decreased ovary size as well as follicle diameter and development.

ERYTHROCYTE FRAGILITY AS AFFECTED BY SOYBEAN PRODUCTS. W. E. Thomas, R. D. Mochrie, W. W. G. Smart and G. Matrone, *N. C. State College.*

Experience at the N. C. State Hygiene Farm has indicated that soybean hay is not a suitable ration for "bleeder" sheep because the red cells hemolyze more quickly in physiological saline. Ten mature sheep were paired and fed either a soybean meal-soybean hay diet or a cottonseed meal-grass hay diet for ten weeks. Weekly blood samples indicated increasing fragility for the soybean fed sheep during the early part of the trial, whereas the control group changed very little (P less than .01 for quadratic). The cells from the soybean fed sheep continued to be more fragile during the last four weeks of the trial (P less than .10). The effects of soybean hay on fragility of calf blood were not conclusive. When 10 one week old Jersey calves were fed soybean hay for 12 weeks and changed to oat hay for approximately four weeks, there was a significant increase in erythrocyte resistance to hemolysis. However, when 17 similar calves were fed either oat hay or soybean hay from one week to 13 weeks of age, the red cells of the oat hay fed calves were slightly more fragile (P less than 0.05).

BIOLOGICAL ASSAY OF BEEF STEER CARCASSES FOR ESTROGENIC ACTIVITY FOLLOWING THE FEEDING OF DIETHYLSTILBESTROL AT A LEVEL OF 10 MG. PER DAY IN THE RATION. Chas. W. Turner, *Missouri Agricultural Experiment Station.*

A control lot of 10 Hereford steers and a lot of 20 animals receiving 10 mg. daily of diethylstilbestrol were fed for 148 days. The diethylstilbestrol was with-

drawn 44 hours before slaughter. Composite samples of 21 tissues, organs, depot fat, digestive tract and blood from the two groups were obtained for bioassay for residual estrogen. A comparison was made to determine the effect of graded doses of diethylstilbestrol added to control rib-eye tissue using as assay animals young sexually mature ovariectomized mice with normal weanling mice. The sensitivity of the assay method was about 2 parts per billion. Ovariectomized mice were used in all assays. Using the comparison of the uterine stimulation induced by the control and experimental tissues and by the effect of added diethylstilbestrol, it was concluded that the edible red meat, rib-eye, neck trimmings and tongue were free of residual estrogen. The following glands and organs: liver, heart, spleen, and brain were also free of hormone. The kidneys showed evidence of estrogen to the extent of 4 parts per billion while the lungs indicated the presence of 10 to 12 parts per billion of residual estrogen. The depot fat at 25 and 50 percent levels and the blood showed no evidence of estrogen nor did the various parts of the digestive tract.

PALPATING UDDERS TO INVESTIGATE THE SELECTION OF HIGH MILK PRODUCING EWES. J. L. Van Horn, A. S. Hoversland and O. O. Thomas, *Montana Agricultural Experiment Station.*

The udders on 346 Rambouillet ewes were palpated and scored at weaning time. The scores ranged from 1 to 4, with 1 being very large and full and 4 being almost dry. Scores from 6 to 10 were given to ewes with abnormal udders or ones which had nodules or blue bag. Weaning weights were taken on the lambs at the time the ewes were scored. The average weaning weight of the lambs raised as singles from the ewes scored were as follows: score 1, 89.7 lb.; score 2, 87.4 lb.; score 3, 81.6 lb.; and score 4, 80.4 lb. The average weaning weight of the twin lambs from the ewes scored from 1 to 4 were, 73.6, 71.2, 68.1 and 63.4 lb., respectively. The udder scores for ewes which raised twins were higher than for the ewes which raised singles. Sixty-six percent of the aged ewes which raised twins had an udder score of 1 or 2; 57 percent of the ewes with singles were in this category; and only 27 percent of the two-year-old ewes scored 2 or higher. Nine ewes either had nodules in their udders or previously had active cases of blue bag. One side of the udder in 11 ewes was not functioning, and the other side contained a watery fluid. Ten of these ewes had lambs which were slightly below average in weaning weight.

REPRODUCTION PERFORMANCE OF CATTLE GRAZING GRASS VERSUS CLOVER-GRASS PASTURE AS INFLUENCED BY COTTONSEED MEAL SUPPLEMENTATION. A. C. Warnick, E. Bedrak, M. Koger, A. G. Lewis and T. J. Cunha, *Florida Agricultural Experiment Station.*

The average calving percentage over two years in 29 nonsuckled and 68 suckled cows grazing clover-grass pastures was 86 and 59 percent, respectively, while corresponding percentages in 32 nonsuckled and 60 suckled cows grazing all grass pastures was 78 and 0 percent, respectively. Eleven nonpregnant parous cows were grazed on clover-grass pastures and 30 comparable cows were grazed on all grass pastures. One-half of the cows on each pasture received 1.5 lb. daily of 36 percent cottonseed meal during the winter period of 1953–54 and the others received no supplemental protein. There was a 100 percent calf crop in all groups except those on grass without protein which was 75 percent. The average calving date was December 26 in clover-grass fed, January 2 in clover-grass nonfed, January 9 in grass fed, and March 17 in grass nonfed cows. Sixteen 18 month old heifers were grazed on clover-grass pastures and 18 comparable heifers were grazed on all grass pastures. One-half of the heifers on each pasture received 1.5 lb. daily

of 41 percent cottonseed meal during the winter of 1954–55. The average interval to estrus after breeding began on February 2 was 16, 7, 17 and 39 days in the clover-grass fed, clover-grass nonfed, grass fed and grass nonfed heifers, respectively. The average percentage of pregnancies in the above groups varied from 80 to 89 percent. Protein supplementation had a beneficial influence on reproduction in all grass pastures but not on clover-grass pastures in this experiment.

ESTRUS IN RANGE EWE LAMBS AND ITS RELATION TO SUBSEQUENT REPRODUCTION. Earl L. Wiggins, *Western Sheep Breeding Laboratory.*

Information on the occurrence of estrus was obtained on 2386 range ewe lambs by allowing vasectomized rams equipped with marking harnesses to run with the ewe lamb band during the winter. Some estrual activity was observed from September to late February but the majority of the lambs had their first heat from the middle of November to the last of December. The percentages of lambs having one or more heat periods their first winter were 15.9, 14.5 and 15.0 for lambs born in 1952, 1953 and 1954, respectively. Of the 138 lambs born in 1954 that were in heat, 61.6 percent had one heat period, 24.6 percent had two, 8.0 had three, 3.6 had four and 2.2 percent had five heat periods. Average inbreeding coefficients for lambs in heat and lambs not in heat in the 3 years were: Rambouillets, 16.3 and 17.1; Targhees, 5.9 and 8.3; Columbias, 7.8 and 11.4 percent. Corresponding averages for other traits were: Weanling face covering score, 3.48 and 3.54, 2.82 and 3.00, 2.60 and 2.62; weanling condition score, 2.49 and 2.83, 2.13 and 2.49, 1.98 and 2.40; weanling body weight, 75.2 and 69.4, 80.4 and 73.3, 84.0 and 75.8; yearling body weight (shorn) 85.5 and 80.4, 87.4 and 81.2, 88.5 and 85.0. Two year old lamb production figures for ewes born in 1952, listed in the above order were: Percent ewes lambing 97.5 and 91.3 (40 and 173 ewes), 96.0 and 89.4 (25 and 132 ewes), 66.7 and 84.4 (9 and 83 ewes); lb. lamb weaned per ewe at lambing 60.2 and 48.5, 68.3 and 66.3, 43.0 and 49.0.

OVARIAN HORMONES FOR SUCKLING LAMBS FATTENED ON PASTURE. W. S. Wilkinson, R. C. Carter and J. S. Copenhaver, *Virginia Polytechnic Institute.*

Forty-eight suckling lambs were divided into six groups and two groups assigned to each of three treatment pellets, as follows: I, parraffin, control; II, 10 mg. estradiol and 250 mg. progesterone; and III, 250 mg. progesterone. Individual lambs in one group within each treatment were implanted with the pellet subcutaneously in the ear at 35 lb. body weight; the other group was implanted at 50 lb. Twenty-four additional lambs were divided into four groups and used to replicate treatments I and II. Lambs were creep-fed until turned on pasture. Values were obtained for daily gain, live grade, carcass grade, and dressing percentage for all lambs and also for the weights of pelt, viscera, pluck and liver, carcass length, external fat thickness, and percentages of moisture, ether extract and nitrogen in a boned-out, ground carcass composite for three lambs within each group in replicate one. Treatments had no significant effect on daily gain, regardless of weight at implanting. Groups I, II, and III gained 0.566, 0.578, and 0.566 lb. daily, respectively. Average dressing percentages for groups I, II, and III were 50.5, 49.0 and 49.9, respectively. Average live grade for all lambs was choice. Carcass grades were: group I, 1 prime, 21 choice, 5 good; group II, 10 choice, 12 good; group III, 4 prime, 3 choice, 8 good. One lamb each in groups I and III was disowned by the ewe; five lambs were lost from prolapse in group II. In general, group II lambs had larger values for pelt, viscera, and liver weights, carcass length, percentage of water and nitrogen in the carcass; smaller values for external fat thickness and percentage ether extract in the carcass; and no difference in pluck weight compared to group I.

TESTICULAR SIZE AND PRODUCTION OF SPERMATOZOA BY BULLS. E. L. Willett and J. I. Ohms, *American Foundation for the Study of Genetics.*

Measurements were made *in situ* of testes of bulls after slaughter and of volume of the excised glands. Of the measurements made, the equivalent in a standing bull of the horizontal circumference at the point of greatest size gave the highest correlation with the volume of the two glands as measured by water displacement. The correlation coefficient was 0.94 with 53 bulls. In another study with 16 bulls the correlation between excised testis weight and volume was 0.99. The correlation between scrotal circumference (two measurements on each bull) and spermatozoan production over a period of 5 months of 72 bulls in regular service in studs was 0.32. The correlation with number of services held constant was 0.30. Corresponding correlations from another study with 47 bulls in regular service over a period of one year were 0.46 and 0.43. Eight bulls were exhausted 8 times with each exhaustion followed by a single ejaculate 1, 3, 5, or 7 days later and then by an additional rest period of 7 days. The correlation between scrotal circumference and total spermatozoan production was 0.68.

A STUDY OF THE EFFECT UPON FARROWING AND LACTATION OF SPRAYING BREEDING GILTS WITH BENZENE HEXACHLORIDE BEFORE AND DURING GESTATION. Richard F. Wilson and A. W. Jordan, *Ohio State University.*

Two lots of five gilts each were compared in each of three years in which one lot was sprayed with beneze hexachloride (.25 percent solution of the gamma isomer) an average of 8.4 days before breeding, 16.8 days after breeding and again 57.1 days after breeding. The other lot of gilts was not sprayed with the insecticide but was housed and fed with the sprayed gilts during gestation and lactation. Some difficulty was experienced in getting the gilts to settle from first service in both lots during the three years. All gilts farrowed. No difference could be attributed to the use of the insecticide during gestation in the following: ability to conceive, length of gestation period, number of pigs farrowed, strength and weight of pigs at birth, pig loss to weaning, and number and weight of pigs at weaning. Further data will be reported wherein the feed of gestating gilts has been contaminated with benzene hexachloride.

THE ANTITHYROTOXIC VALUE OF LIVER RESIDUE AND FISH SOLUBLES FOR THE PIG. D. W. Zinn and G. C. Anderson, *West Virginia University.*

In previous work liver residue and fish solubles improved the performance of growing pigs, but the response was small and often erratic. In order to emphasize the possible need of the growing pig for an unidentified factor(s) and to more clearly evaluate liver residue and fish solubles as sources of such a factor(s) stimulation with iodinated casein was employed. Three trials were conducted with Berkshire and Duroc pigs ranging in weight from 30 to 70 lb. Rations in which the major source of protein was supplied by soybean oil meal or a combination of soybean oil meal and meat scraps or tankage were full hand-fed in dry lot. Levels of 52, 112 or 164 mg. of iodinated casein per pound of ration were used, but only the higher levels imposed observable symptoms of thyrotoxicosis although all levels depressed growth and decreased feed efficiency. The presence of 3 or 5 percent liver residue in the rations counteracted the effects of iodinated casein but 5 percent of fish solubles was ineffective. The antithyrotoxic value of a combination of liver residue and fish solubles could be ascribed to the liver residue.

Extension Section

Charles E. Bell, *Chairman*

A FIVE YEAR STUDY OF WEIGHT-GAINS AND FEED CONVERSION OF BEEF CATTLE IN MAINE. H. H. Brugman and H. C. Dickey, *Maine Agricultural Experiment Station.*

Thirteen farmers cooperated in the study. Cattle were weighed fall and spring on the farm of the cooperator using a portable scale as described in the JOURNAL OF ANIMAL SCIENCE, page 74–80, February, 1954. Weight-gains and feed conversion were marginal and monetary returns over feed cost were negative in several cases. Use of tested bulls with an index of 2.4 lb. average daily gain showed an improvement in the performance of the calves. Bulls with higher indices should be used to make the beef cattle industry in Maine profitable else the beef cattle operator will discontinue the enterprise in spite of the excellent and abundant grassland that is available in the State of Maine.

A YEAR'S RESULTS OF OHIO SWINE EVALUATION. W. H. Bruner, *Ohio State University.*

The first year's operations of the Ohio Swine Evaluation Station found 101 breeders participating, representing 9 breeds with 210 litters evaluated. Objectives—To improve commercial swine by selecting breeding stock that indicates absence of inherited defects, prolificacy, nursing ability, gaining ability, efficiency of feed utilization, and carcass value. Procedure—(1) Breeder nominates litter within ten days after farrowing. (2) Weight standards (21, 35 or 56 days) prescribed by the appropriate breed applies. (3) Committee inspects litter and selects representative pair of pigs for the station. (4) Pigs are self-fed a standard ration from 63 days of age to approximately 210 lb. weight. Pens and equipment for each pair of pigs are identical. Feed requirement is 370 lb. or less per 100 lb. gain. (5) Pigs are weighed at bi-weekly intervals. The pair of pigs must average 200 lb. at no more than 180 days of age. (6) Carcass data secured at the Meats Laboratory, Ohio State University. Results—Certification of record for remaining boars and gilts in a litter is performed by the Swine Improvement Assn. of Ohio. A primal cut yield of 47 to 49 percent is certified Ohio Commercial and 49 percent or over is certified Ohio Superior. Forty-three of 102 (1954) fall litters were certified Ohio Superior. Record analyses reveal that the Superior litters required no more feed per 100 lb. gain and gained as fast as the non-Superior litters. The Superior litters had less back fat, larger loin eye (10th rib), and a greater percentage of live weight in the trimmed primal cuts. Correlation between age at slaughter and 63 day weight was —.514.

NEWS AND NOTES

1955 Annual Meeting. The annual meeting will be held at Hotel Sherman, Chicago, on November 25 and 26.

The Nominating Committee of the American Society of Animal Production has proposed the following list of candidates to be presented at the annual business meeting: for President, L. E. Casida; for Vice President, J. E. Foster, and J. C. Miller; for Secretary, W. M. Beeson.

The Executive Committee wishes to announce a change in the policy of the Portrait Committee of the Saddle and Sirloin Club and that the Society will not present a portrait in 1955. As stated by William E. Ogilvie, Secretary of the Portrait Committee, "The only change of policy affecting the acceptance of portraits as it applies to the American Society of Animal Production is that a portrait of its honor guest can no longer be accepted on an *annual basis,* because nearly all of the available space on the Club walls is now occupied with portraits of leaders of the agricultural industry. This situation has been foreseeable for some time and it has become necessary that the acceptance of portraits be curtailed. Only two portraits have been approved for the gallery this year, in contrast to the four or five annually in the past, and submissions of course will continue to be considered for the ensuing years as they are presented."

"This policy in no way entails discrimination against college men since all recommendations of individual members of the American Society of Animal Production will be considered on a comparable basis with leaders in other phases of the animal, meat and related interests. There are presently in the gallery portraits of 38 college men from 20 Land Grant institutions, which is more than are associated with any other particular agricultural field."

O. E. Reed retired September 1 as director of livestock research for USDA's Agricultural Research Service. Dr. Reed joined the Department in 1928 as head of Dairy Research and served for 26 years as chief of the former Bureau of Dairy Industry until his appointment in 1954 as director of livestock research.

Paul E. Howe retired July 31 after having been identified with the animal and poultry husbandry research staff of the USDA at Beltsville, Md., for more than 30 years. Dr. Howe joined the animal husbandry staff in 1924 and was in charge of nutrition investigations until 1936; he served as chief, Animal Nutrition Division and assistant chief of the former Bureau of Animal Industry 1936–1948, and nutrition consultant from 1948 to the date of his retirement. In addition to his service in the Department of Agriculture, he rendered extensive service on human nutrition problems during and immediately following World Wars I and II, and later as nutrition advisor to the U. S. Bureau of Prisons and National Defense Council.

Julius E. Nordby returned in May from a two-year assignment in Egypt and has resumed his duties as Director of the U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory, Dubois, Idaho.

B. T. Simms has been named Director of livestock research for USDA's Agricultural Research Service, to succeed O. E. Reed. Dr. Simms has been Chief of the Animal Disease and Parasite Research Branch since 1954, and previously served as Chief of the Department's former Bureau of Animal Industry for nine years.

C. E. Terrill has been named head of the Sheep, Goat and Fiber Research Section, Animal and Poultry Research Branch, Beltsville, Md. Damon A. Spencer,

who has been in charge of this Section for many years, will continue in charge of farm sheep investigations. Dr. Terrill has been associated with the U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory, Dubois, Idaho, since 1937, and served as Director during the past two years.

E. J. Warwick, formerly Regional Coordinator of the Southern Regional Beef Cattle Breeding Project, has been named head of the Beef Cattle Research Section, Animal and Poultry Husbandry Branch, Beltsville, Md.

William E. Shaklee has joined the professional staff of the State Experiment Stations Division, Agricultural Research Service, with responsibilities in the field of animal breeding and genetics.

E. J. Turman, former assistant professor of animal husbandry at Purdue University, has joined the animal husbandry staff of the Oklahoma A. & M. College. He will be engaged in teaching and research on dwarfism in beef cattle.

J. V. Craig has moved to Kansas State College where he will be engaged in teaching and poultry breeding research.

Paul R. Noland has accepted a two year assignment in Panama. His new address is Arkansas Agricultural Mission, P. O. Box 785, Ancon, Canal Zone.

James R. Stouffer has accepted a position as Assistant Professor of Animal Industry at the University of Connecticut.

Burdette C. Breidenstein has accepted a position as Assistant Professor of Meats at the University of Illinois.

George L. Robertson, formerly Associate Professor of Animal Husbandry at Texas A. & M. College, succeeded Professor J. B. Francioni, Jr. as Head of the Animal Industry Department, Louisiana State University, effective July 1, 1955.

James L. Carmon, who recently received his Ph.D. degree from North Carolina State College in Genetics and Statistics, has accepted a joint teaching and research assignment in the Animal Husbandry Department of the University of Georgia.

James W. Lassiter, who recently received his Ph.D. degree from the University of Illinois in the field of Nutrition, has accepted a joint teaching and research assignment in the Animal Husbandry Department of the University of Georgia.

Merle R. Light has joined the Animal Husbandry instruction staff of Iowa State College. Mr. Light was formerly a member of the Animal Husbandry Department of North Dakota State College.

Dr. Bruce R. Taylor has been appointed Associate Professor of Animal Husbandry at Iowa State College. Dr. Taylor will be engaged in Animal Nutrition teaching and research.

Duane Acker, who has been doing graduate work at Oklahoma A & M College, has joined the Animal Husbandry Department of Iowa State College as instructor.

George E. Combs, who has recently finished his Ph.D. in Animal Nutrition at Iowa State College, has been appointed Assistant Professor and Assistant Animal Husbandman in the Department of Animal Husbandry and Nutrition at the University of Florida. He will assist Dr. H. D. Wallace in the swine work.

Dr. Frank H. Baker, formerly a member of the Animal Husbandry staff at Kansas State College, has accepted an appointment as Associate Professor of Animal Nutrition at the University of Kentucky to replace Dr. Charles M. Thompson who resigned to accept a position with the Beardstown Mills Company, Beardstown, Illinois.

Eugene Francis resigned as Extension Animal Husbandman at Iowa State College to accept a position as Secretary and Treasurer of the St. Joseph Livestock Exchange at St. Joseph, Missouri.

The Second World Congress on Fertility and Sterility will be held May 18 to 26, 1956 in Naples, Italy.

Dean Dale H. Sieling, of the University of Massachusetts, has announced the combination of the dairy industry and animal husbandry departments into one department to be called dairy and animal science. Dr. D. J. Hankinson, formerly head of dairy industry will head this new department. Professor Victor A. Rice, formerly head of animal husbandry and a faculty member for 39 years, retired as of September 1, to become director of instruction in the School of Agriculture at North Carolina State College.

John L. Hobart has been appointed instructor at the University of Massachusetts in the subject matter area of meats and general livestock.

Verne A. Adams has been appointed instructor of meats and general livestock at the University of Massachusetts.

Dr. Martin Sevoian, of the pathology and bacteriology department at the New York State Veterinary College, has been appointed a research professor in the veterinary science department of the University of Massachusetts.

Joe B. Johnson, Oregon State College, is on sabbatic leave to the State College of Washington. George E. Nelms is taking over Mr. Johnson's duties.

David C. England has been appointed assistant professor at Oregon State College to coordinate research in livestock and to develop cooperative research on farms.

Paul C. Berger has been appointed instructor supervising livestock and farms at Oregon State College.

William W. Ellis has been named instructor in animal nutrition at Oregon State College.

Carrol W. Fox will leave Colorado A and M January 1, 1956 to become assistant professor in charge of wool technology and sheep husbandry at Oregon State College, succeeding O. M. Nelson who has retired.

Cecil Peirce has resigned his position at Oregon State College to join a Commercial firm in California.

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